Electrical Engineering

May
1934

FIFTIETH
ANNIVERSARY
AIEE
1884 - 1934

Published Monthly by the
American Institute of Electrical Engineers

TO THE lasting memory of those public spirited leaders who founded and built to its present eminence the American Institute of Electrical Engineers, and to the inspiration of those of the present and future generations who will continue the constructive leadership of this agency for professional development, this issue of ELECTRICAL ENGINEERING is dedicated upon the occasion of the fiftieth anniversary of the Institute's founding, May 13, 1884.

Published Monthly by

American Institute of Electrical Engineers

(Founded May 13, 1884)

Electrical Engineering

Registered U. S. Patent Office

May 1934
Volume 53
No. 5

The Official Monthly Journal and Transactions of the A.I.E.E.

PUBLICATION OFFICE, 20th and Northampton Streets, Easton, Pa.

EDITORIAL AND ADVERTISING OFFICES, 33 West 39th Street, New York, N. Y.

ENTERED as second class matter at the Post Office, Easton, Pa., April 20, 1932, under the Act of Congress March 3, 1879. Accepted for mailing at special postage rates provided for in Section 1103, Act of October 3, 1917, authorized on August 3, 1918.

SUBSCRIPTION RATES—$12 per year to United States, Mexico, Cuba, Porto Rico, Hawaii and the Philippine Isalands, Central America, South America (except Argentina), Haiti, Spain and Spanish Colonies; $13 to Canada; $14 to all other countries. Single copy $1.50.

CHANGE OF ADDRESS—requests must be received by the fifteenth of the month to be effective with the succeeding issue. Copies undelivered due to incorrect address cannot be replaced without charge. Be sure to specify both old and new addresses and any change in business affiliation.

ADVERTISING COPY—changes must be received by the fifteenth of the month to be effective for the issue of the month succeeding.

ELECTRICAL ENGINEERING is indexed in Industrial Arts Index and Engineering Index.

Printed in the United States of America. Number of copies this issue—

18,100

This Month—*50th Anniversary Number*

General

—Turn to next page

The Fiftieth Anniversary of the A.I.E.E.

By J. B. Whitehead, President A.I.E.E. 1933-34

With a glorious record of tradition, accomplishment, and unique service to profession and to society; with no apparent causes for regrets; and with the promise of the future that lies in firmly planted ideals, the Institute may justly take for itself a happy celebration of its anniversary.

IN CELEBRATING the fiftieth anniversary of the founding of the American Institute of Electrical Engineers, it may also be said that we are celebrating also a similar birthday of the electrical art. The period in which the Institute was founded was that in which the applications of electric power were just beginning to expand beyond the fields of the telegraph, the telephone, and other signal systems which, while already highly developed and rapidly growing in public service, nevertheless were strictly limited in character of service, and commonly involved currents and voltages of relatively low values. However, electric lighting by arc and incandescence also was well on its way, and the first New York Edison central station already was a reality. Evidently the time was ripe for the birth of the profession of electrical engineering.

Similar stirrings from similar causes were occurring in other countries. The Société Française des Électriciens has just at this writing celebrated the fiftieth anniversary of its foundation, thus antedating the A.I.E.E. by a few months. The British Institution of Electrical Engineers was not to see its formal foundation until 1888, but in fact it was already existent in the Society of Telegraph Engineers and Electricians. In other countries, similar societies also were the forerunners of the later expanded organizations with wider scopes.

A most interesting account of the conditions in the electrical art in America in 1884 is to be found in a paper by the distinguished English electrical engineer, W. H. Preece, F.R.S., who was one of a delegation of British scientists and engineers attending an electrical congress in Philadelphia, called for ratifying the Paris units of current, electromotive force, and resistance. Others in the delegation were Lord Rayleigh, Sir Oliver Lodge, and Sir William Thompson. Full of appreciation of the hospitality and courtesy extended everywhere in America, Mr. Preece complains of its summer heat, and also of the dearth of electrical papers and discussion at the joint meetings of the conference and the American Association of Arts and Sciences. He mentions as outstanding topics "The Seat of the Electromotive Force in a Voltaic Cell," the announcement of the Hall effect, and Rowland's claim that the Paris standard for the ohm was not accurate. He notes the advanced state of development of the continuous-current constant-potential generator in this country, but states that in visits to many cities, he did not see an alternating current machine, although they were then quite common in England.

Other literature of this time reflects the continuing interest in methods of measurement as related to telegraph and telephone circuits, the first appearance of direct-reading portable measuring instruments for continuous current lighting and power, and the beginnings of the theory of alternating current and auxiliary equipment. Such a narrow field, so few workers, such limitations for experimental development, well may serve for contrast with the wide complexity and extent of the development of the electrical art today, for evidence of how far we have advanced, and for an appreciation of the vital part played by the Institute.

In one respect a fiftieth anniversary has an advantage over the hundredth and others thereafter. Men are still living who are able to survey the entire past history and so, from personal contact and knowledge, are in admirable position to weigh the significance of the different events and personalities that have had an influence on subsequent development and present status. Many present members of the Institute can trace their identification to its first decade, and a few even to its earliest years. The memories of these men contain great stores of historic interest and value. An effort has been made to garner some of these stores in the series of articles of personal reminiscence by past-presidents of the Institute, which is the chief feature of this anniversary issue of ELECTRICAL ENGINEERING. These articles are indeed the chief feature of our celebration in the reminders they give us of the aims and accomplishments of our distinguished members of the past. These personal reminiscences doubtless will revive similar ones in the memories of others. May I suggest to these that they make permanent records of such reminiscences, sending them to the Institute so that they may play their part in completing the history which is in course of preparation.

Anniversaries are commonly the occasion for looking backward, for a balancing of performance against earlier aspirations, and for a refurbishing of ideals for guidance in the future. Such self-examination may leave us in serious or in happy mood according to the degree of excellence of the past record or to the promise for the years to come. It must be admitted, however, that in the celebrations of anniversaries the happy mood usually predominates:

The successes are dwelt upon; the shortcomings are reserved for more private attention. This is as it should be, for inspiration, enthusiasm, and courage for the future spring more readily from a review of past achievement than of vain regrets, if any, for lost opportunities.

As the American Institute of Electrical Engineers approaches its fiftieth anniversary, in my opinion it may give itself over heartily and with free conscience to the happiest type of celebration, for the Institute has remained true to its ideals, has rendered magnificent service, and set its professional standards on the highest plane. Through successive years those entrusted with its guidance have adhered to the vision of the founders that the basic purpose of the Institute is the advancement of the theory and practice of electrical engineering and of the allied arts and sciences. Efforts have been made from time to time to divert the interest of the Institute to commercial, political, and social problems as related to the electrical art, which, from their nature, are not subject to accurate analysis, are invariably controversial in character, and so tend to disrupt the other sounder unity of interest. The present strength of the Institute in my opinion is due largely to the firmness with which it has insisted that its best service and functions are in the support and development of the scientific basis of the electrical art. This is its strength and the basis of its independence. If I were asked to name the 2 grounds upon which the present strength of the Institute exists, I would place first the record of progress as found in its printed pages, and second the power that its meetings and publications have of attracting aspiring young men, and maintaining their allegiance. Throughout its life in my observation, this appeal to young men has been the greatest asset of the Institute. Beyond question this appeal is inherent in the Institute as the inspiration and the forum of scientific effort and progress in the electrical art.

With a glorious record of tradition, accomplishment, and unique service to profession and to society; with no apparent causes for regrets; and with the promise of the future that lies in firmly planted ideals, the Institute may justly take for itself a happy celebration.

Dr. Wm. Gilberd shewing his experiments on electricity to Queen Elizabeth and her court

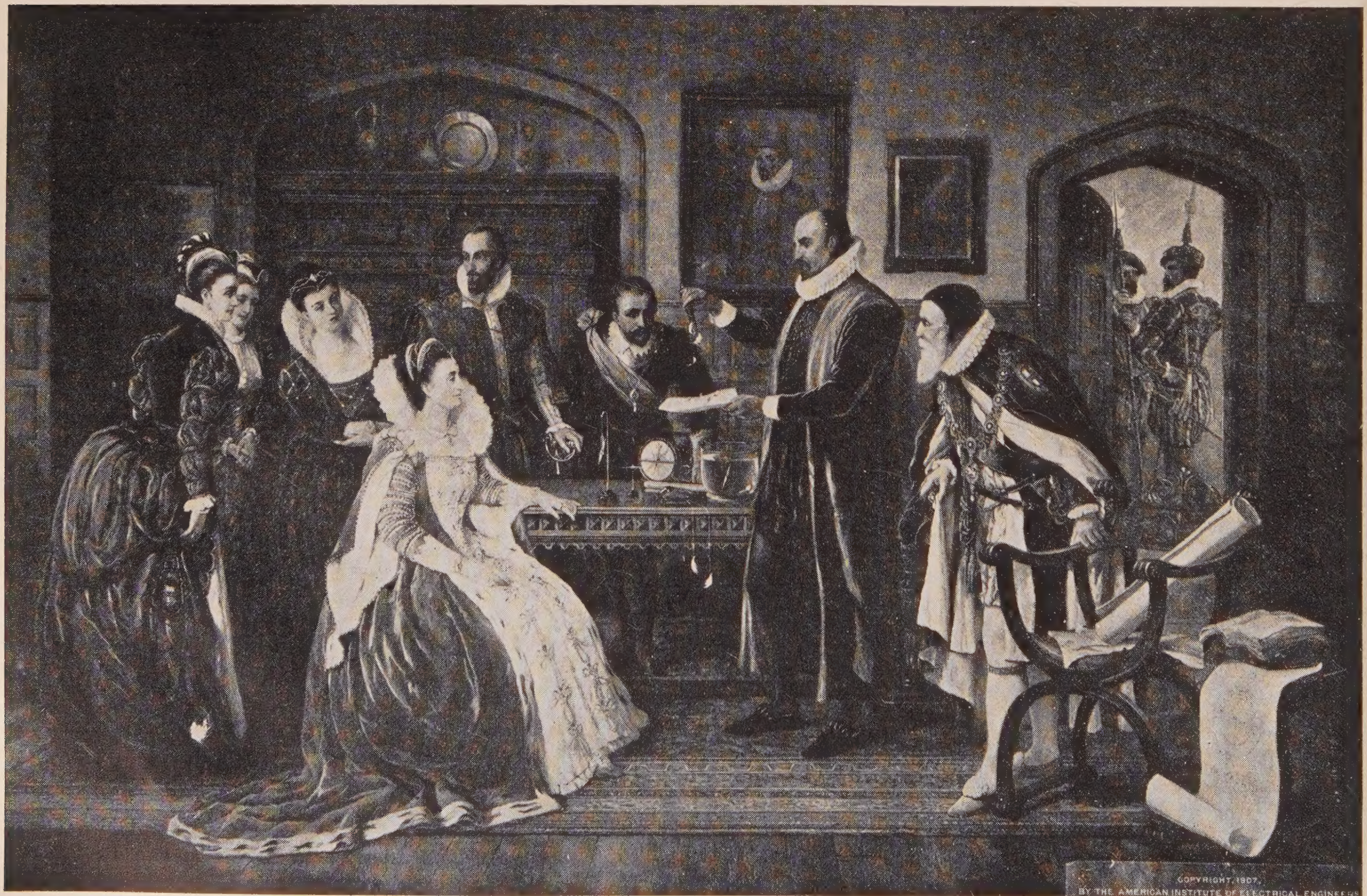
A painting by Arthur Ackland Hunt, replica of that in the Town Hall of Colchester, England, commemorating the Three Hundredth Anniversary of Dr. Gilberd's death on the 10th of December 1903

Presented by the Institution of Electrical Engineers to the American Institute of Electrical Engineers on the occasion of the International Electrical Congress held in St. Louis in September 1904

Bion J. Arnold, President, Amer.I.E.E.

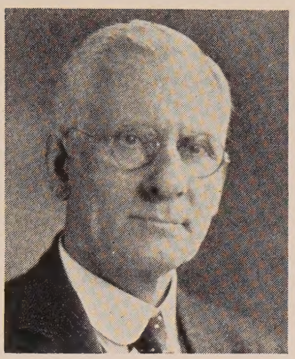
Robert Kaye Gray, President, I.E.E., London

(This is a reproduction of the painting that hangs in the Board Room at A.I.E.E. headquarters, and of the information engraved on the name plate)



Lady Scudamore and Ladies of the Court — Queen Elizabeth — Sir Walter Raleigh — Sir Francis Drake — (Portrait of Gilberd) — William Gilberd, M.D. (1544–1603) — Cecil, Lord Burleigh

The Institute's First Half Century



By Chas. F. Scott

President A.I.E.E. 1902–03

Some highlights in the life of the A.I.E.E., its heritage, and the environment that has shaped its humble beginning and later tremendous growth, are outlined in this article by a past-president whose record of service to the Institute is surpassed by few, if any, other members. Far from being a mere chronological recital of events, this history contains personal reminiscences of many of the Institute's noted personalities and of their struggles and triumphs. Professor Scott says "the perusal of old-time records, the reading of past-presidential contributions of wide variety, personal reminiscing with old-timers and with others have awakened interesting recollections and have given me a new viewpoint and a perspective of various happenings; these now present a significance which one does not recognize when enmeshed in details." Perhaps Professor Scott's contribution will do as much for other members of the Institute.

THE MILESTONES, 1884 and 1934, which mark the first half century of the A.I.E.E., also designate periods in our national history. The early 30's mark recovery from the Civil War and the deression of 1873 and also the beginning of great hanges in our industrial, economic, and social life timulated by the Centennial Exposition in 1876. Electricity, then a novelty, has been so influential n these changes that we call this period "The Age f Electricity." Following the rapid acceleration ame unbalance; economic and social progress is ot meshing in with technical and industrial adance, and in these early '30's we are pausing for eadjustment.

The story of the accelerating second half of a Century of Progress" and the story of electricity ive meaning and significance to the history of the .I.E.E. What part has the A.I.E.E. had in the evelopment of The Age of Electricity and in bringng about the new social order?

The combined threefold story—related in detailed ccount of persons and machines, of inventions and pplications, of processes and products, of causes nd far reaching effects—would be an encyclopedic ask. Nor is the present confused situation suitable or the evaluation of influences and results; that nust await a perspective view which the future may eveal.

The happenings of the present are fruition of the hift from adherence to traditional thought and action to scientific methods and progressive change initiated by the scientists of former centuries. Slowly accumulating scientific knowledge afforded a basis for the inventions and engineering that produce our present changes. Economic and social diagnoses of present conditions, now appearing in profusion, substantiate the predictions of George S. Morison (presidential address, American Society of Civil Engineers, 1895, and "The New Epoch," 1903) that manufactured power would create far-reaching and continuing changes and its advent was the most important factor in human progress since the invention of written language. He foresaw radical readjustments throughout the whole range of life during coming centuries, and he indicated the potency of electricity in the new order. In the long range view, "The New Deal" is a preliminary readjustment in "The New Epoch."

Our present task, however, is to study the career of a national organization of electrical engineers during the past half century, to discover its contribution to the industry and to general progress, and to note the effects of its environment on its own development as an organization.

Our Heritage and Environment

An institution, like a man, is the product of heredity and environment as well as individual initiative and effort. Our Institute has a notable heritage and a stimulating environment.

A painting in the board of directors' room at Institute headquarters signalizes the shift from mere knowledge of certain magnetic phenomena and the electric properties of amber to their experimental investigation. This painting portrays "Dr. William Gilberd shewing his experiments on electricity to Queen Elizabeth and her court"; a reproduction of it may be found on p. 644, this issue.

A recent book on the beginning of modern science refers to Doctor Gilbert (or Gilberd) as follows:

"First in time among the scientists who were to usher in a new era was Dr. William Gilbert (1540–1603), the learned physician of Queen Elizabeth. His work, *De Magnete Magneticisque Corporibus et de Magnete Tellure Physiologica Nova* (London 1600), was the first book that contained nothing of peripatetic natural philosophy, did not despise observation in deference to authority, but which was based entirely upon experiment and showed great skill in the use of the experimental method in the investigation of new phenomena." ("The Role of Scientific Societies in the Seventeenth Century," Ornstein, Chicago University Press, 1928.)

"De Magnete" came to the Institute in the Wheeler gift of the Latimer Clark library. It is a noble book, in heavy covers with gold embellishments. Concluding the title page is ANNO MDC. The volume is printed in Latin, in large clear type, and is divided into 6 books and 115 chapters on 240 pages of over 300 words each.

Gilbert, our electrical pioneer scientist, was succeeded during the next half century by Galileo, Torricelli, Pascal, Kepler, Harvey, Bacon, Descartes, Guericke, leaders in an "incredible revolution in man's ways of thinking and doing."

Following Gilbert by a century and a half, Benjamin Franklin wrote to a friend in England, about 1750, that on account of unfavorable weather he was temporarily discontinuing his interesting experiments with frictional electricity, expressing chagrin that they had produced nothing "of use to mankind." Franklin also wrote about this time that the application of science to human affairs might some time within a thousand years lead to great changes—possibly in agriculture double results might be produced with half the effort. Past-president Jewett's contribution to this issue indicates how prompt and ample has been the fulfillment of Franklin's prophecy.

From Static Sparks to Dynamos

A half century later Volta (1800) announced a new source of electricity. "Static" electricity with its instantaneous discharge in the lightning flash or in the spark from a Leyden jar was supplemented by the flowing current of a battery. Then many investigators of the new current—Davy, Oersted, Ampere, Faraday, Sturgeon, Ohm, Henry—noted its mechanical, magnetic, chemical, thermal, and luminous effects. Then followed by inventors who produced the commercial telegraph, the telephone, electrotyping, electroplating, gas ignition, fire alarms, and signals; but primitive lamps and motors found the cost of battery current prohibitive.

Then in 1831 came Faraday's fundamental discovery of electromagnetic induction, which lured scientific and ingenious pioneers by the vision of superceding the battery by transmuting mechanical power into electricity. They were legion. Sylvanus P. Thompson's classic "Dynamo Electric Machinery" names about 50 during the decades following 1831 whose attempts at dynamo making found record in print. Out of it all came a menagerie of queer forms. Thompson's treatise in the '80's shows 32 forms of magnetic fields employed in dynamos, only a few of which suggest the circular yoke with radial multipoles, now all but universal. One with 2 armatures and only one field pole for each (not shown by Thompson) mystified the Electrical Conference of '84. In the Dunham Laboratory at Yale University are pioneer machines employing a dozen types of magnetic circuits. Nevertheless they worked, and they ushered in the new era of cheap electric power.

Physical, Intellectual, and Social Environment

All of this development would have been of little avail had there not been contemporary development of the steam engine. Not only were these engines ready for driving dynamos, but men had become power users; the machinery and methods that underlay the industrial revolution were based on power. So the stage was set for more power and better power—unfettered by the rigid limitations as to distance of transmission, control of speed, and divisibility incident to mechanical power.

Likewise in transportation. Here the first great event after the prehistoric invention of the wheel was the locomotive, then completing a half century of service; but the locomotive, like the stationary engine, was not practicable in small units, and there resulted a wide gap between the horse and the big locomotive. Furthermore the horsecar service on city streets, which began about 1860, covered some 4,000 miles in the early '80's. People were ready for something larger and faster and more comfortable.

Likewise in lighting. The oil lamp with its smoking flame, little changed through a dozen centuries, had adopted whale oil, and the whaling industry had been closed by oil from the earth. My father was a college freshman when he first saw a lamp chimney. Coal oil (kerosene) lamps in general use and the open flame of gas in the cities through their excellence and their limitations gave electrical inventors an inspiring vision of what might be.

Electroplating by battery current was the doorway to a great field in electrochemical industry which cheap power could make practicable.

In communication, 40 years of the telegraph since the Morse historic message on May 24, 1844, and telephone service inaugurated by the opening of the first commercial exchange in New Haven,

onn., January 28, 1878, had made the public keen r the improved facilities that inventors were riving to supply.

The heritage from early scientific workers—the xperiments of Faraday and the theories of Maxell—was reinforced in the '80's by the scientific ıen of the time. While the organizations of civil ıd mining and mechanical engineers came largely om men of experience in old time professions, our ectrical society, with less of tradition, needed ience. The professors of physics were alert; ote those taking part in the Electrical Conference ı 1884. Of the 12 members of the officially apointed committee 10 were professors; about the ıme proportion took part in the proceedings, nor re they all mentioned in the accompanying review f the conference. Among others were Prof. Cleveınd Abbe of the U.S. Signal Service, Professor John 'rowbridge of Harvard University, and my own ormer professor, T. C. Mendenhall, who signed a eport on atmospheric electricity. At the first ession of the A.I.E.E. also the professors were quite ı evidence, while 5 of the Institute's first officers ere designated as professors.

These professors were not merely theorists and alkers—they set about to train men. Electrical ngineering curricula did not originate in the estabshed departments of engineering, but in departıents of physics. There they remained until, as 'rofessor Jackson points out in his accompanying ontribution, he, himself, initiated the electrical ngineering department in 1890. The transition t Yale was made when I went there in 1911.

Engineering schools have had a profound influence n the development of the electrical profession and ıdustry. These schools, primarily civil or mining, umbered half a dozen in 1860 and over 4 score in 880. Engineering graduates were appearing, suplementing the practical men in industry, and they 'ere ready to develop and adopt new methods. 'arly electrical students may have had the fortunate cientific sponsorship of departments of physics, ut they were primarily engineering students rather han physicists. In short, the engineering school, etting under good headway in the early '80's, prepared the man-power for the professional and inustrial developments that soon followed.

MERICAN IDEALS

All these conditions played their part in the realiation of the American dream—the ideal of a new nd better way of living, a new freedom in religion nd government and thought, and also freedom from ıe struggle and toil that pioneer life imposed. The)eclaration of Independence opened the way to ne freedom, while the simultaneous appearance f the steam engine made the other possible. A entury later the dynamo arrived to make engine ower a hundred times more effective in relieving the oil and increasing the opportunities and comforts ıat have been a vision of the American dream.

The history of America has been largely the hisory of the pioneer struggling with nature on the dvancing western frontier until the frontier reached the Pacific just after the founding of the Institute. Then came new pioneers, applying science through engineering to conquer and control the forces of nature in the advance of civilization.

Again in longer perspective: The coming of Science brought a shift from tradition and the old ways of doing things to the idea of a better way and the effort to find it. The new principle of progress had become ingrained in American thought and life; it dominated the spirit of the engineer who had built canals and railroads and mills and factories. The electrical engineer—obsessed with the idea that through discovery and invention and engineering application he could make electricity of continually greater "use to mankind"—found himself a Progressive in a receptive world of progress.

From the Centennial, 1876, to the Founding of the Institute, 1884

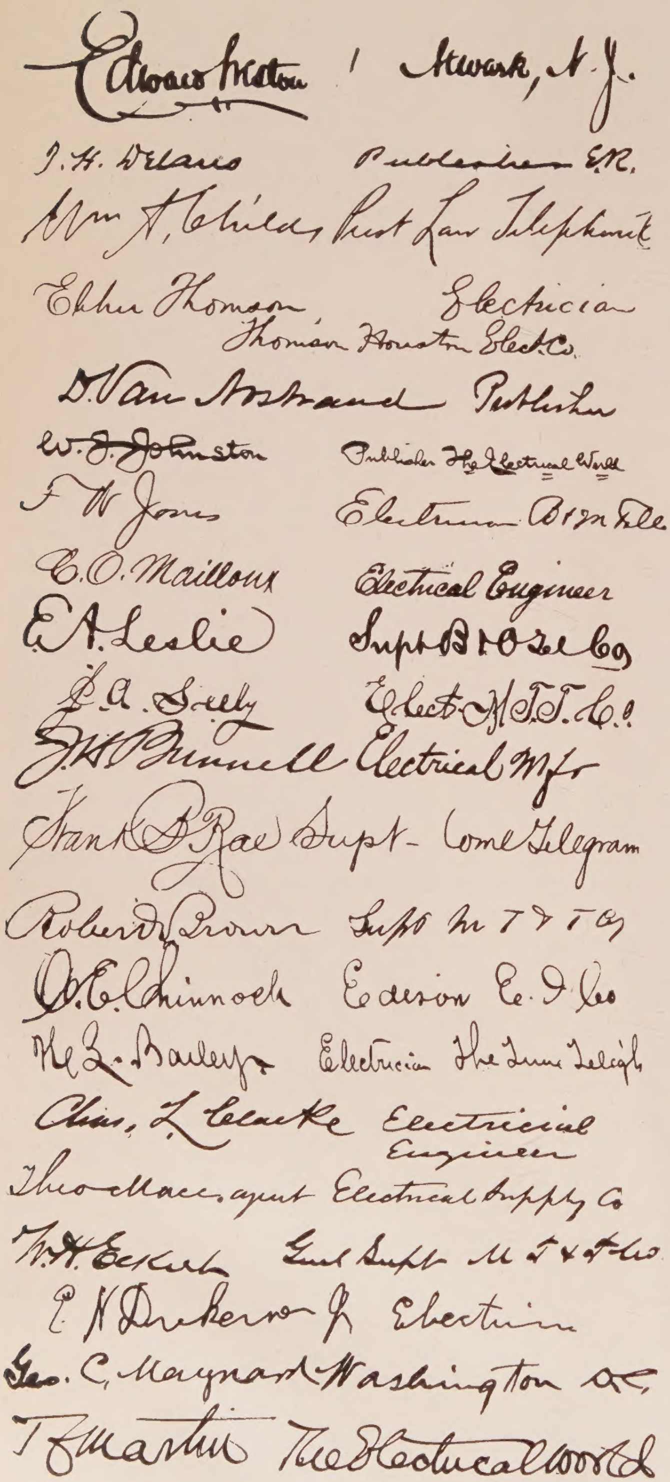
On Prof. Elihu Thompson's 80th birthday anniversary last year, I asked him just what electrical machinery was at the Centennial Exposition in Philadelphia in 1876. His face brightened and there was a sparkle in his eye. "Well, I'll tell you," he said; "there was a Gramme machine that ran one arc lamp, and another Gramme machine wound for electroplating; and a Wallace dynamo that operated an arc lamp on top of the building." (The first, I understand, was from France, the second was made by Professor Anthony of Cornell University, and the third was made in Ansonia, Conn.) Thomson's interest in electricity was aroused and he was soon an electrical expert performing tests. Fifty years later in 1928 the Franklin Institute in Philadelphia celebrated the semicentennial of the first test of dynamo efficiency. Professor Thomson (charter member and past-president of the Institute) had made the test on a Brush machine.

Mr. Charles F. Brush (charter member and Honorary Member of the Institute) outstanding pioneer in arc lighting was present and told a fascinating story of his early work in making dynamos and lamps in his machine shop. He described difficulties of various kinds, particularly with insulation and in getting 2 lamps to operate on the same circuit. Professor Thomson then told of the test and pointed, it seemed to me with affectionate regard, to the exact location of apparatus in the same room in which he was speaking. Mr. E. W. Rice (past-president of the Institute) who had aided Professor Thomson also spoke. These men, pioneers at the beginning of the new industry, were all in fine health and vigor.

By 1884 there were arc lamps in the streets of many cities and towns, representing various "systems"—Brush. Thomson-Houston, and others. Each arc machine supplied its own circuit of, say, 10 or 25 or more lamps connected in series, usually taking 10 amperes.

As the arc light was too intense for general use indoors, the great problem of those days was the "subdivision of the electric light." Edison, intent

on independent switching, like turning gas on and off, developed a fine filament which would take but a small current and thus involve small expense for conducting wires. The largest dynamo at that time suitable for contant voltage would supply only 25 16-candle power lamps. Hence not only lamps but conducting circuits and dynamos had to be developed for the opening of the Pearl Street Station in New York City—great because of incandescent lighting, but even greater as a means of distributing electric power and making energy a common commodity. On September 4, 1932, I heard over the radio the celebration of the 50th anniversary of the opening of the Pearl Street Station, partly from New York and partly from Mr. Ford's Edison Museum at Dearborn, Mich., where the original engineer started one of the original engines and Jumbo dynamos.



Some Well Known Signatures

Among the 21 signatures appearing above are those of 5 living charter members, 3 of whom became officers, and the signatures of 5 other past officers, together with a few of the prominent signers of the original "call" for the organization meeting of May 13, 1884

Electrical Pioneers

Electric cars were being undertaken by Edison, Field, Daft, Van Depoele, Bentley-Knight, Henry, Sprague, and others. It was the day of individualism; the ideal of each was in general a complete self-contained system. There were workers also with storage batteries and with electroplating. In the older groups new telegraph systems were being devised and telephones were extending. There were secrecy and rivalry and competition.

The age-long fascination of electricity intensified as the new dynamo, a source of cheap electric energy, "made it of use to mankind." Edison from telegraphy, Brush from the machine shop, Thomson and Houston, teachers of science, Keith from chemistry, Sperry from his freshman year at Cornell, Sprague from the Naval Academy, Weston from electroplating, Bell, a worker for the deaf, are typical of these pioneers.

Professors of physics took interest in the new developments. Investors and promoters were alert. All of these groups of ingenious, inventive, resourceful yet heterogeneous workers, some concerned with the older "small" currents and others with the new "heavy" currents, had a common bond—electricity.

Engineers Organize; A.I.E.E. Beginnings

In the early '80's there was a shift among engineers from individualism to group organization: witness the Engineers Society of Western Pennsylvania, 1880; The American Society of Mechanical Engineers, 1880; the American Water Works Association, 1881; the New York Electrical Society, 1881; a reorganization forming the Western Society of Engineers, 1882; the Association of Railway Telegraph Superintendents, 1882; the American Street Railway Association, 1882 (later the American Street and Interurban Railway Association); the Civil Engineers Society of Connecticut, 1884; the National Electric Light Association, 1885; the Association of Edison Illuminating Companies, 1885.

Electrical engineers were in condition favoring crystallization, which was precipitated by the announcement of the International Electrical Exhibition, sponsored by the Franklin Institute, to be held in Philadelphia in the fall of 1884. I well remember when Secretary Pope introduced me to

Doctor Keith, a chemist, as the founder of our Institute. He was of medium stature, quiet and pleasant, and his advancing age was apparent. He initiated a call in April 1884 for a meeting of electrical men. The call and the original signatures hang in the Institute parlor. Among the signers were T. A. Edison, and 7 who became presidents: Norvin Green, F. L. Pope, T. C. Martin, Edward Weston, Elihu Thomson, E. J. Houston, and C. O. Mailloux; also George A. Hamilton who was treasurer for 35 years. Following a preliminary meeting April 15, a committee worked out a scheme of organization. On May 13, 1884, the rules proposed were adopted, officers were elected, and the American Institute of Electrical Engineers was formed. The next event was the Philadelphia meeting, September–October, 1884.

The telegraph industry contributed the first president and over half of the vice-presidents and managers on the first council (see article in this issue by Donald McNicol). Those who entered the new electric light and power field were young men. In 1915 I compared the ages of the preceding 12 presidents of several national societies. The average age of the civil engineering presidents was 60, of the mechanicals 57, while that of the electricals was 44. Only 1 of the electricals' presidents was over 47, and only 2 of the other presidents were under 50. My own age at the time of my presidency, 38, was less than any other in these groups. T. C. Martin was less than 38 when he became president.

The A.I.E.E. Prospectus, April 1884

The circular issued in April by Doctor Keith, which received many signatures and initiated the Institute, reveals that the initial ideas of plan and scope were quite broad. The whole 7 paragraphs are well worth perusal. The essentials are these:

"The rapidly growing art of producing and utilizing electricity has no assistance from any American national scientific society."

The American civil, mechanical, and mining engineering societies are prosperous and of advantage to their members.

Foreign visitors to the International Exhibition to be held during the coming autumn should be received by a national electrical society.

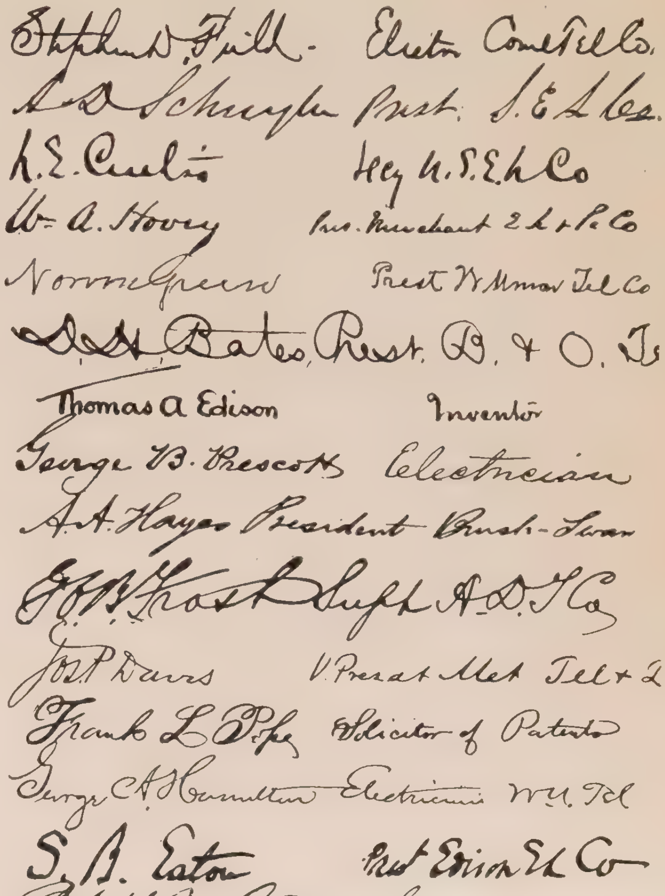
It is proposed to follow the model of existing engineering societies whose "members assemble, read, and discuss papers and matters relating to their trades or professions and at the same time enjoy pleasant personal and social intercourse, all of which is conducive to improvement and advancement in ideas, theories, practice, business, and good fellowship."

"Persons who are interested in our electrical scientific educational, manufacturing, telegraphic, telephonic, and like concerns as well as the users of electrical appliances generally, will find it to their advantage, personally and collectively, to establish, work for, and generally aid our proposed society."

"It is proposed to make electrical engineers, electricians, instructors in schools and colleges, inventors, and manufacturers of electrical apparatus, officers of telegraph, telephone, electric light, burglar alarm, district messenger, electric time, and of all companies based upon electrical inventions as well as all who are inclined to support the organization for the common interest, eligible to membership."

Publication of "papers, discussions, and transactions and affiliations with sister societies, a museum, library, original research, protection from unfavorable legislation, settlement of disputed electrical questions, exchange of transactions with other societies, a journal of abstracts of papers read before other societies or published in other journals, etc., etc., are all proposed."

This indicates cosmopolitan eligibility as it includes those who are "inclined to support." The ample list of proposed activities inspires admiration



Some Well Known Signatures

Among the 24 signatures appearing above are those of a living charter member and past officer, the signatures of 12 other past officers, and some of the prominent signers of the original "call" for the organization meeting of May 13, 1884

of the vision of a future that might require a double "etc." While the first paragraph calls for a scientific society, the idea of pure science is considerably diluted in the list of proposed interests.

The early record says the document was signed by "electricians, capitalists, and others connected with electrical enterprises or interested in the advancement of electrical science." Presumably engineers were included under either "electricians," or "others."

Original Rules Adopted May 13, 1884

The propagandic call sold the idea, and the objects and membership are defined more conservatively in the Rules adopted at the organization meeting, the first portion of which is as follows:

"The objects of the American Institute of Electrical Engineers are to promote the Arts and Sciences connected with the production and utilization of electricity, and the welfare of those employed in these industries; by means of meeting for social intercourse, the reading and discussion of professional papers, and the circulation, by means of publications among its members and associates, of the information thus obtained."

"The Institute shall consist of Members, Honorary Members, and Associates. Members and Honorary Members shall be professional electrical engineers and electricians. Associates shall include persons practically and officially engaged in electrical enterprises, and all suitable persons desirous of being connected with the Institute, and duly elected as hereinafter provided...."

State of the Electrical Art in 1884

Three events give snapshot pictures of conditions in the electrical world when the Institute began. They were an Electrical Exhibition held at Philadelphia in September and October 1884; a 6-day Conference of Electricians at the Exhibition during the first month, and the first technical session of the newly formed American Institute of Electrical Engineers during the second month. What was observed at the Exhibition and summaries of the 2 technical meetings throw light on the state of the art and afford interesting views of personalities.

Electrical Exhibition

At the Electrical Exhibition conducted by the Franklin Institute in Philadelphia during September and October 1884, a receptive college student was in charge of an exhibit. What he saw he recorded in the accompanying contribution of Past-President D. C. Jackson. Particularly striking was the attempt of Brush to make his arc light high voltage circuit operate incandescent lamps and appliances in the home. Notes of the Exhibition also are made by past-presidents Sprague and Rice.

The Exposition is summarized in an editorial in *The Electrical World*, October 11, 1884. The fact that N. S. Keith, the founder of the Institute, was associate technical editor, and that he participated in both of the technical meetings held at the Exposition, gives a clue to authorship of the editorial which follows in slightly condensed form.

"The Close of the Exhibition"

"... .It was fortunate that a body like the Franklin Institute should be found ready to plan and carry out an exhibition for this country, and electricity as a science and art owes a debt to the Institute for the prominence that has been given it. ...

"... .One valuable feature of the Exhibition has been the assemblage within its walls of large numbers of the leading scientific men of this country and Europe, members of the various learned societies. The meetings of the American Association for the Advancement of Science, of the National Conference of Electricians, of the American Institute of Electrical Engineers, of the Telephone Convention and of the Association of Railway Telegraph Superintendents, have been highly important and interesting, and electricians have separated after them feeling that they know a good deal more of each other and of the science to which all are devoting their lives. We esteem it no small thing that on a common platform the best electricians of the two hemispheres have met and exchanged notes and opinions, and have learned to entertain for one another higher feelings of respect and admiration.

"The Franklin Institute, adhering to a time-honored policy, has endeavored to make the exhibition distinctly educational in character. Here again it has succeeded. Even admitting the complaint of a few that the public school pupil scheme was a little overdone, and that exhibitors would have been pleased with the attendance of fewer sweet girl graduates and rivals of Peck's bad boy, the fact remains that thousands of people, young and old, have made their first direct acquaintance with electrical principles and apparatus through the Exhibition, and have acquired a thirst that they will never lose for knowledge on the subject. The great sale of the electrical primers shows how eager the public is to master the science for itself.

"Though the Exhibition did not present to notice many very great novelties, it was a good, representative collection of apparatus and instruments new and old, and will take its place with the Exhibitions of Paris, Vienna, Munich, and London. It has not been without a stimulus to inventors, and no doubt many developments will date back to Philadelphia 1884. An inventor will sometimes work on languidly, trifling, and dallying with an idea that, insignificant as it may seem, is full of potency. Suddenly, as at the Philadelphia Exhibition he realizes that other minds besides his are exploring along the line on which he believed himself to be a solitary traveler; and the mere knowledge that other men see something in the distance, in that direction, too, is one of the sharpest spurs his inventive genius can be prodded with. Moreover, as the inventor looks on the old homely electromagnets of Prof. Henry or on the early telephones of Bell and others, or on Morse's first telegraphic instruments, or on the old Wallace dynamo machines, and then looks around on the 2,500 exhibits representing the electrical inventions and industries of today in which hundreds of millions of dollars are invested, he derives a stimulus of another kind. If fame and the desire to be first at the goal cannot bring him more quickly along the road, there is the inducement of solid wealth.

"The Exhibition closed today, but its effects and results will be experienced through many years."

At the head of the editorial section of the same issue is printed in bold face type:

This paper is printed on a Cottrell press, by a Daft electric motor, at the International Electrical Exposition, Philadelphia.

On the same page is reference to a controversy among certain newspapers as to which should have credit (during the early part of 1884) for the first electric motor-driven presses. Another item, in the issue of November 8, 1884, which is significant because it received neither emphasis nor comment, is titled "Long-Distance Electric Lighting." It is copied from the London *Electrician* and described tests at the Turin Exhibition of a 25-mile transmission by alternate current produced by a "Siemens dynamo machine, of the 30 horse-power type." Gaulard and Gibbs secondary generators were employed in several localities for supplying lamps of various kinds. (The primary coils of the secondary generators or transformers were connected in series.)

Conference of Electricians, September 1884

The National Conference of Electricians held September 8 to 13, 1884 in Philadelphia gives us a snapshot of electrical history in the month preceding the first technical meeting of the A.I.E.E. Papers were read and discussed and recommendations were made.

The National Conference of Electricians was conducted by a scientific commission appointed by the President of the United States. Professor Henry A. Rowland, physicist of John Hopkins University was chairman. Several representatives from England were in attendance. A report of nearly 200 pages was printed as "Ex. Doc. No. 45, 49th Congress, 1st Session" (It is now out of print.) It is included in Volume 1 of "The Executive Documents of the Senate of the United States for the First Session of the Forty Ninth Congress." The report of the conference was printed in current issues of *The Electrical World*.

Professor Rowland gave an interesting historical scientific résumé. In it he signalized Franklin's ability in connecting isolated observations into theory, such as that of positive and negative electricity equal in amount; he invented charge and discharge by cascade; he showed that it was the glass and not the coating of a Leyden jar that contained the charge. Professor Rowland concluded by saying "Let physical laboratories arise...let technical schools also be founded.... It is not telegraph operators but electrical engineers that the future demands."

In his remarks as vice-president of the conference Sir William Thomson (Lord Kelvin, Honorary member of the Institute) stressed the importance of an international system of electrical measurement and the laying out of international standards. He commended the twofold object of the conference—promoting the useful applications of science to the ordinary wants of man and giving character and vigor to the investigator.

The Dynamo Electric Machine

Atmospheric electricity, standards of electrical quantities and of light, and the establishment of a national bureau of physical standards were discussed. Regarding the latter Doctor Keith, initiator of the Institute said: "The time is coming, as Sir William Thomson has so happily suggested, when house to house lighting and utilization of electric energy is to become extensive. Meters have been devised and will be devised to measure this electrical energy, hence the necessity of a bureau of standards to be utilized by the various cities in making a determination of the meters we shall be obliged to use." A committee was appointed to represent the conference before Congress in relation to the establishing of the bureau.

"The Theory of the Dynamo Electric Machine," before the principles of the magnetic circuit were recognized, was an excursion into a fog. Various types of magnets for 2-pole dynamos are shown in half a dozen figures. In the discussion we find this: "Mr. Elihu Thomson: I have been at work on dynamo machines for a long time and my experience teaches me that some of the statements brought forward are not correct." He then specified half a dozen points.

Professor Rowland, who had opened the symposium, introduced the next session thus: "I am very glad to see the matter taken up in this spirit and to have my principles intelligently criticized." The discussion relates very largely to the magnetic field—its form, shape, size, material, and the characteristics of hollow and of concentric cores. One paragraph begins: "Professor Elihu Thomson: I do not agree that those induced currents can be abolished by dividing up the cores." Professor Sylvanus P. Thompson brings up many controversial points. Others participating were Professor Fitzgerald of Dublin, Mr. Keith, Professor George Forbes of London, Professor Anthony of Cornell, and Professor Nipher of St. Louis. The latter in dealing with "The Electric Transmission of Energy" on the following day discussed motor characteristics. If this be included in the discussion of dynamo-electric machines this topic occupies over 25 per cent of the technical record. Here was controversy as to the relations of theory and practice, but much of the discussion seemed to be based on the cut and try method.

Storage Batteries

Regarding "Storage Batteries" Mr. W. H. Preece (head of the British Postal Telegraph, later Sir William Preece, Honorary Member of the Institute) who had been called on somewhat unexpectedly, said "Mr. Edison himself has declared that this question of storage batteries has the most remarkable power of developing man's latent capacity for lying. (Laughter.) I very much agree with Mr. Edison's definition, for I think there has been more lying, more swindling, and more rascality over this question of storage batteries than over any other department of electrical science." So one may note that a half century has produced not only chemical and mechanical but moral development as well.

Mr. Preece said incidentally that secondary batteries (he disliked "storage") furnished electric light in the (British) post office, also in his own house, "where a gas engine works a Gramme dynamo which gives me 42 volts and 52 amperes...when my gardner comes on duty in the morning he lights the gas and charges the battery... I have at my bedside a most charming mellow light, with no smoke, no wick, no heat, by merely turning a tap. I have never had any bother except when the gardner put his foot on the wrong place and the head of the gas engine came down on it and he had to lose 4 toes. Their removal reminds him of the danger of electric lighting. (Laughter.)" Within a few months of this time a student at Ohio State University while starting the new gas engine electric plant lost a toe by similar accident.

The Otto engine ran a 3-light Thomson-Houston arc machine and a 15-light Edison dynamo in the physics laboratory at the university.

Mr. F. J. Sprague remarked "With a gas engine there is difficulty in starting. A person has to put his foot on the flywheel and pull it around before he can get it started. If he simply uses a secondary battery he can light his gas engine and it will start ahead all right." Mr. Preece feeling sympathy for the battery commented "I look upon the employment of a battery for any such purpose as simply barbarous." Little did he foresee that the greatest use of the battery would be for that purpose.

Others discussing batteries included Professor Carhart (of Carhart standard cell fame) Mr. Keith, Professor Thomson, Professor Houston, Lieutenant Jewell, Professor James Dewar of Cambridge, England, Professor Rowland, Mr. Koegh, and Professor Forbes. The discussion covers nearly as many pages as that on dynamo-electric machines.

Telephones and Other Topics

A symposium on "Induction in Telephone Wires, Long Distance Telephoning, and Underground Wires," was opened by Mr. T. D. Lockwood, of the Bell System with some general observations: "Twenty years since, when electricity was a mere branch of physical science—when we referred to the telegraph in its several forms, to electrolysis in its applications to electrotyping and plating, and to the miscellaneous practical operations of gas lighting, burglar and fire alarms, and to electro-therapeutics, we have substantially scanned the electrical field of that day." He reported that "An Essay on Electricity" written in 1792 contained the expression "As electricity is in its infancy,...."

Mr. Lockwood discusses various items of interest, among them the use of a complete metallic circuit instead of the then commonly used ground return: "It is probable that for such persons as desire to communicate frequently between distant cities loop lines will be built, adapted to form extension of the trunk metallic circuits."

Other subjects discussed were "The Electrical Investigation of the Physical Qualities of Structural Materials" (fatigue) by Captain O. E. Michaelis; "Measurement of Large Currents" by Mr. Keith; "Applications of Electricity to Military and Mining Engineering" by Captain Jewell; and "Lightning Protection" (primarily of buildings) by professors Rowland and Houston.

In concluding the Conference Mr. Alexander Graham Bell moved a vote of thanks "to our distinguished vice-president, Sir William Thomson, and to the other distinguished electricians from abroad" for coming and participating. Mr. Keith announced the formation of the A.I.E.E. and its coming session.

Mr. Preece spoke of the pleasure the visitors had experienced in becoming personally acquainted with their professional friends: "I have noticed a slight tendency to consider criticism as personal and unnecessary, and the debate has at times been a little warm, but personal meetings of this kind entirely eradicate that feeling."

On motion of Professor Simon Newcomb by whom the conference had been opened, it adjourned.

The Institute Papers at the First Session, 1884

"Notes on Phenomena in Incandescent Lamps," by Professor Edwin J. Houston (Illustrated) the first title at the initial technical meeting of the Institute in October 1884 does not sound at all startling, nor do the initial sentences, "I have not prepared a paper, but merely wish to call your attention to a matter I presume you have all seen and puzzled over. Indeed I wish to bring it before the Society for the purpose of having you puzzle over it. I refer to the peculiar high vacuum phenomena observed by Mr. Edison in some of his incandescent lamps." Later Professor Houston remarks: "I believe we shall find the preceding phenomena worth looking into. For my own part I am somewhat inclined to believe that we may possibly have here a new source of electrical excitement." And so our Institute, concerned primarily with the new ways of producing and using electric power, viewed a new puzzle, little dreaming what it might portend. (See p. 654.)

Last September from a meeting of the New York Electrical Society an address by Dr. C. H. Sharp was broadcast on "Edison's radio tube of 1883." The high spots are as follows:

> In investigating the blackening of lamps Mr. Edison introduced a wire between the legs of the lamp filament and brought out a third terminal. He found that if this third wire were connected through a galvanometer to the positive leg of the filament a current flowed between the filament and the wire.
>
> Professor J. A. Fleming next carried out a systematic investigation of the effect; and as a result produced the Fleming valve, the first device purposely made as a radio detector dependent upon electronic action. Doctor Lee DeForest took the next step by introducing the principle of the control of the flight of the electrons by means of an auxiliary electrode, a stroke of genius which elicited admiration of Mr. Edison. Thus the modern radio tube was evolved from the "Edison effect" lamps of 1883.

At the conclusion of Doctor Sharp's address a replica of the original "tube" was employed and demonstrated as part of a receiving set.

Thus the Institute, born under the quickening impulses of the new era of "engineering electricity," presented in the first paragraph of its first paper a puzzling observation—the Edison effect—which through the Fleming valve and DeForest's audion later ushered in another era, that of electronics.

"Underground Wires" and Other Topics

"Underground Wires," the second paper, by W. M. Callender of the Callender Company, stated that such wires were in satisfactory use for telegraph, telephone, and incandescent lighting, but as to arc lighting "the feelings of the light companies toward the underground question is one of great caution and unbelief"—feelings based upon sad experience. Vulcanized bitumen which receives "a peculiar secret treatment" is stated to have proved satisfactory in Callender wire in English use—"a fortunate circumstance as the American public are clamoring for the removal of the unsightly poles which disfigure their streets." Mr. W. H. Preece said that underground wires in England "is a problem that has been solved" and pointed out various differences between conditions in the 2 countries.

"Synchronism" (accomplished by the Delany synchronous-multiplex system of telegraphy) was presented by Professor Houston.

"The Scientific City Street" was described by R. R. Hazard, president, Gramme Co. A frontispiece shows a cross section of Broadway, New York City, with 4 tunnels for trains under the street and spaces under the sidewalks for pipes and wires. Such a scheme was said to be possible since electricity (instead of steam locomotives) is "entirely within the present resources of the art."

"An Experimental Method of Studying the Dynamo Machine" was presented by Professor C. F. Brackett of Princeton. "Its principal feature consists in the use of an exploring coil to determine the relative value of any point of the magnetic field in which the armature revolves."

In another paper, carrying the title "Earthwires; or, the Earth as an Electric Circuit Completer," Thos. D. Lockwood, electrician, American Bell Telephone Company, presents a historical account followed by descriptions of earthing devices. He had been "long impressed with the preëminent importance of the subject."

"Telegraphing without Wires—An Experiment," by S. J. M. Bear, was not our "wireless," but a scheme in which the 2 terminals of the sending circuit (battery and key) were connected respectively to a copper earth-plate and a zinc earth-plate emersed a little way apart on one side of a tub of water, while the relay was connected to a copper earth-plate and a copper plate emersed in a porous cup containing sulphate of copper, near the other side of the tub.

"Chemistry of the Carbon Filament," by Edward P. Thompson, M. E., is a technical paper, but contains this interesting information: "The principal lamps now being largely manufactured and represented at the Exhibition, and in which the filaments differ from one another by distinct chemical reactions which take place in their manufacture, are the Edison, the Swan, the Weston, and the Stanley and Thompson lamps." In the discussion Mr. Keith suggested that several gentlemen connected with various companies say something about their processes but got very little response.

"Depositing-Vats in 'Series'" for electroplating was stated by Mr. H. B. Slater to be simply a descriptive paper presented by request. In discussion of that paper is found: "Mr. Keith: As our honorable guest, Mr. Preece, has said to me, 'This is your hobby,' I may be supposed to say something. I have a paper prepared on this subject embracing the laws which govern it and some remarks as to...the production of pure metals... I have investigated it extensively since 1876." Mr. E. A. Sperry participated in the discussion.

The Patent Office

"The Patent Office: Its Relation to Inventors and Its Needs," is longer and provoked more discussion than other papers, although "it was only upon Saturday last" that it had been requested. It is by Mr. C. J. Kintner, chief examiner of the Class of electricity in the U. S. Patent Office. He depicts the significance of invention, and "how the telegraph, the telephone, the railroad, and thousands of other inventions have increased a thousandfold the field of labor." He outlines the organization and procedure in the Patent Office with its total force of 550. He indicates inadequacy and proposes remedies which inventors and business interests concerned with inventions should bring about. This first request to the new Institute met response in later years through American Engineering Council, which among other things protested against a proposed reduction in patent office salaries that would have dispersed experienced personnel and also aided in a revision of patent office procedures by adding the engineering to the legal viewpoint.

Six months earlier at the Institute's organization meeting, May 13, 1884, a letter from Mr. Kintner was received setting forth the inadequacy of his facilities for meeting the demands. Following are some of the items relative to his electrical division:

"Cases awaiting action, 374; force, 8 assistants and 2 clerks.

"This division embraces electrical appliances pure and simple, and has grown in 4 years so far as to include over 6,000 patents.

"Prior to July 1, 1880, there were less than 2,000 patents which disclosed any electrical appliance or apparatus whatever. Since that time, the rapid advance made in telephony, telegraphy, electric lighting appliances, dynamo machines, etc., has placed the division foremost in the arts....

"The rooms are badly ventilated... In my own room there is no gas and I am obliged to use kerosene oil which vitiates the atmosphere."

What are the present activities of the Patent Office, which recently moved into new quarters, for comparison with those of 50 years ago? A request for such information brought the following reply from the Commissioner of Patents:

Dear Mr. Scott:

In the succeeding paragraphs I am giving you the facts you requested in your letter of February 16, 1934, already acknowledged:

Nine divisions of the Patent Office are devoted exclusively to electrical classes. These are Divisions 16, 26, 37, 42, 48, 51, 54, 60, and 65. An aggregate of 84 examiners is employed in these divisions. The electrical divisions are on the average about 3 months behind current dates. As of January 27, 1934, the number of cases awaiting action was 5,643.

The following classes are directed entirely to inventions in various branches of electricity, but they are not, of course, completely comprehensive in that respect:

Class		No. of Patents
13	Electric Furnaces	1,932
136	Batteries	5,110
171	Electricity, Generation	12,665
172	Electricity, Motive Power	9,367
173	Electricity, Conductors	10,300
174	Electricity, Medical & Surgical	1,397
175	Electricity, General Applications	11,206
176	Electric Lamps	5,452
177	Electric Signaling	8,113
178	Telegraphy	5,487
179	Telephony	15,849
191	Electricity, Transmission to Vehicles	5,731
200	Electricity, Circuit Makers and Breakers	17,941
201	Resistances and Rheostats	2,238
204	Electrochemistry	5,471
219	Electric Heating	8,398
247	Electrical Conduits & Housings	2,709
250	Radiant Energy	6,980
290	Prime Mover Dynamo Plants	1,652
105	Railway Rolling Stock, Electric locomotives	456
	Total	138,454

Many other classes, such as Class 246, Railway Switches and Signals, 16,481 patents; Class 161, Time Controlling Mechanism, 1,672 patents; and Class 240, Illumination, 16,533 patents, include a very large percentage of patents having electrical features therein. These classes cannot, however, be regarded as strictly electrical. Through all the classes in the Office the use of electrical devices and mechanisms and processes, in combination with and in the art, machine, or process where they occur, is claimed.

Many of the patents in the various classes date back a century or more. Some of the older of these patents are instanced below:

Class No.	Patent No.	Year	Class No.	Patent No.	Year
13...	96,827	1869	176...	20,255	1858
	236,478	1881		20,706	1858
	263,758	1882	177...	1,622	1840
136...	2,521	1842		4,318	1845
	2,984	1843		4,661	1846
	5,400	1847	178...	1,647	1840
171...	3,191	1843		4,453	1846
	5,485	1848		4,464	1846
	10,175	1853		5,612	1848
172...	132	1837	179...	105,552	1870
	809	1838		174,465	1876
	910	1838		197,387	1877
173...	1,096	1839	191...	24,721	1859
	2,056	1841		183,874	1876
	2,284	1841		252,193	1882
	4,807	1846	200...	7,394	1850
	5,889	1848		14,711	1856
174...	D. Harrington..July 22,	1833	201...	25,532	1859
	D. Harrington..Jan. 27,	1834		122,267	1871
	D. Harrington..Mar. 31,	1835	204...	3,015	1843
	4,167	1845		3,698	1844
	4,176	1845		4,012	1845
175...	3,316	1843	219...	48,584	1865
	5,507	1848		88,006	1869
	7,420	1850		121,765	1871
	7,671	1850	247...	69,947	1867
	8,843	1852		96,641	1869

I trust the foregoing will suffice for your purpose....

CONWAY P. COE
Commissioner

This quantitative expansion and qualitative classification give a revealing picture of the state of electrical development today; more than justifying energetic Kintner's prediction in 1884 that we were then "on the verge of a wave of progress such as was never before known to the civilized world."

A.I.E.E. TRANSACTIONS, VOLUME I

TRANSACTIONS of the American Institute of Electrical Engineers, Volume I, May 1884–October 1884 contains a historical preface relative to organization matters, and a general statement regarding the Philadelphia Meeting, September–October 1884. Rooms at the International Electrical Exposition had been kept open by Mr. Keith, secretary, from September 2 to October 11 which "were visited by a great many members of the Institute and by several foreign electricians. On October 7 and 8 a meeting was held . . . where the papers forming part of this volume were read and discussed. . . . (Owing to ill health, Mr. C. O. Mailloux has not been able to prepare for publication in this volume his paper on 'Exploring the Field of the Dynamo-Electric Machine')." Eleven papers are printed in this volume, including, in addition to those discussed at the Philadelphia meeting, a paper "The Delany Synchronous-Multiplex System of Telegraphy" supplementing Professor Houston's paper on Synchronism."

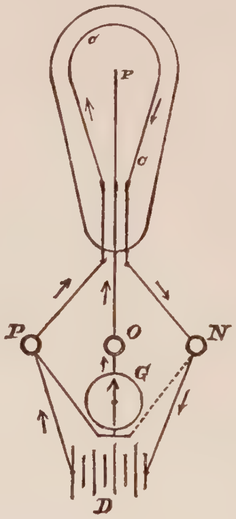
A paper read before the American Institute of Electrical Engineers, at Philadelphia, October, 1884.

NOTES ON PHENOMENA IN INCANDESCENT LAMPS.

BY PROF. EDWIN J. HOUSTON.

Prof. HOUSTON:—I have not prepared a paper, but merely wish to call your attention to a matter which, I suppose, you have all seen and puzzled over. Indeed, I wish to bring it before the society for the purpose of having you puzzle over it. I refer to the peculiar high vacuum phenomena observed by Mr. Edison in some of his incandescent lamps. I have in my hand an Edison incandescent lamp, having the same vacuum as the ordinary incandescent lamp. This one, however, has, in addition to the carbon filament, a platinum plate, or strip, that is thoroughly insulated from the filament, and supported in the manner seen between the two branches of the filament, as shown in Fig. 1.

FIG. 1.



An Edison carbon filament, *c*, *c*, is placed inside an inclosing glass case in the usual manner. A strip of platinum foil, P, is supported as shown inside the loop. The binding posts, P and N,

Page 1 of the first technical paper published in volume I of the A.I.E.E. TRANSACTIONS (see p. 652, column 2)

Reading, Discussion, and Publication of Papers, 1884–1900

The reading and discussion of papers and their publication, supplemented by social meetings were the prescribed means by which the Institute was to accomplish its objects. For nearly 2 decades meetings and papers constituted nearly the whole of Institute activities. A new attitude toward electrical problems then was inaugurated which will be considered later.

The Philadelphia meeting was followed by annual meetings in New York. Then "the importance of the various electrical problems which are continually being brought to public notice" led to the holding of

monthly meetings in New York for "the discussion of current topics." The first was held June 8, 1886, preceded by an informal dinner. The subject of discussion was "Incandescent Lighting From Central Stations." These meetings continued (except during the summer months) until 1918. In March 1894 simultaneous monthly meetings were inaugurated in Chicago, the same paper being read and discussed in the 2 cities. General meetings lasting several days were held regularly each year. As "the national character of the Institute showed the desirability of holding meetings in different parts of the country" the general meeting in 1890 was held in Boston, and in subsequent years in various places.

To secure "recognition for the important researches of Americans" the Institute participated in the International Electrical Congress at Paris in 1889.

Apparently the first constructive technical undertaking was the appointment of a committee in 1889 to formulate "a standard wiring table for light and power purposes." The report was discussed during the following year, and was approved and "entered into engineering practice." (See p. 677.)

In 1891 5 delegates attended the Frankfort International Congress and recommended among other things the adoption of the "henry" as "the name for the practical unit of induction." It also invited the congress to meet in Chicago at the coming World's Fair, which was held in 1893. The technical recommendations were not acted on at Frankfort.

The Institute sponsored the International Electrical Congress in 1893, and established headquarters in the Electricity Building. The register recorded 612 visitors. Shortly afterward 117 were added to Institute enrolment which could largely be traced to the headquarters at the fair. A report on the congress, a volume of nearly 500 pages covering the proceedings of both the official and the general chambers, was issued by the Institute.

The Institute's First Decade

The tenth anniversay of the Institute in 1894 was celebrated at the general meeting of 4 days in Philadelphia. President Houston's inaugural address was entitled "Progress of the American Institute of Electrical Engineers." The following is a condensed version:

> The Centennial Exposition of 1876 had sown broadcast the germs of public interest in electricity. From 1876 to 1884 work in the electrical field was of pioneering nature and of independent character. Each investigator trod the path of discovery alone, often unconscious of the existence of fellow investigators. The time had come for "congregation as opposed to segregation." The exhibits at the 1884 Exposition were a revelation to the hitherto independent workers. The National Conference of Electricians brought professors and investigators in the physical laboratories into contact with inventors and actual workers in the commercial electrical field; but the awakening due to exhibitions and conferences should be surpassed by that of an organized society.
>
> The nature of the influence of the Institute may be noted in a review of its 10-year history (1884–94). The work of its members includes invention, commercial applications, and research in many fields. As a body it made valuable contribution to the Chicago Electrical Congress (notably in scientific standardization) in 1893. It has provisionally adopted names for units and struggled with the definition of "inductance." Parallel with the Institute the electrical press has been a potent factor. England, France, and Germany, as well as this country, owe much of their electrical progress to their national electrical organizations.
>
> Advantages of membership are cited. "Proud of the progress shown" a plea is made for support of a central, organized body deriving authority from a membership extending over the entire country. (Membership 890; annual income and expense, just over $10,000 each. Standing committees: papers, meetings, and editing; library; finance, building, and permanent quarters; units and standards; membership.)

Underwriters Rules

In 1896 a delegate was appointed to a "National Conference on Standard Electrical Rules." The delegate, Professor F. B. Crocker was made president of the conference. Presumably, this was the first participation of the Institute with other national groups. "Underwriters Rules" were sponsored by many national organizations which finally resulted in the "National Electrical Code." It was my privilege as an unofficial delegate from a manufacturing company to attend this conference. Nearly a decade earlier I had been a wireman at a time when underwriter's wire was a matter of course, when rosettes and switch bases and fuse blocks for bare lead fuses were all made of wood, both for lamp circuits and for 1,100-volt station service. I could appreciate the importance of the conference and the significance of a serious joint effort of underwriters, architects, builders, and engineering societies to secure safety and excellence.

In 1899 the Institute took action on a practical matter by recommending "the grounding of one wire of every low potential consumption circuit."

Standardization

On January 26, 1898, a topical discussion was held on "The Standardizing of Generators, Motors, and Transformers." This was an occasion of peculiar significance. It was the first important practical engineering problem taken up for extended discussion and continued consideration (unless the adoption of the wire table 8 years earlier be an exception). The complexity of the problem, the number participating in the discussion, the distinction of the committee appointed and the excellence of the "Report of the Committee on Standardization," accepted June 28, 1899, all make a splendid record; but that was only the beginning of a new chapter in the story of standards, told elsewhere in this issue by past-presidents Kennelly and Skinner.

The report of the standardization committee differed from a "paper" as it was not passively presented by a member, but was actively undertaken and prepared by a committee. The attitude of the committee was not that of research seeking something new, but rather of the judge, who considers various definitions and methods of test and current practices to decide what is best for adoption. Some years later when I was a member of the committee and we were revising the report, a table of standard voltages was being drafted. We selected from those in use the particular values that seemed to make the

best sequence. But when we reached 66,000 volts objection was raised by Steinmetz to going further because it was beyond current practice. I ventured to suggest that if we recommended certain voltages in the higher range they might be selected, for practice and confusion avoided. The suggestion was accepted. This incident indicates the initial principle of crystallizing current practice rather than seeking something different or new.

The preceding account of early Institute activities is based upon the historical sketch of the origin and work of the Institute by Secretary Pope, which appears in the 1900 Institute Handbook. Prominence is given here to activities other than the presentation of the papers, which are preserved in nearly a score of volumes. There is a development seen in the monthly meetings in New York and in the Chicago meetings, in the itinerancy of general meetings after the first few years, in the participation in international congresses, in the participation by invitation in the preparation of the "National Electrical Code," and in standardization, both in the wiring table and in the Report of 1899.

In Mr. Pope's history I find no mention of other engineering societies or relations with them, except the courtesy through which early meetings were held in the house of the American Society of Civil Engineers and later ones at 12 West 31st Street, New York, in the house of The American Society of Mechanical Engineers.

Steinmetz, President 1901–02

At the 1894 (tenth anniversary) meeting there was a discussion relative to the magnetic field in induction motors. As I recall, it was rather desultory and was dragging a bit. Then a distinct, resonant voice amply loud from a corner of the large room, shielded from my view by a pillar, gave a comprehensive summary statement of the whole subject. Then the phenomena in certain particular cases was stated, including the effect of the third harmonic in 2-phase motors and in 3-phase motors. The treatment was as complete and the language as perfect as if the speaker were reading from an article prepared for the "Encyclopedia Britannica." It was Steinmetz talking extempore. (As my recollection does not tally with the printed record, I assume that it was condensed before publication.) This was my first contact with him, although I knew him by reputation through his law of hysteresis and his great paper on complex quantities presented at Chicago which has become a basic method in alternating current representation and calculation.

In 1901 Steinmetz became president. A picture is impressed on my memory. A waiting group in the secretary's office: Steinmetz enters with an apologetic smile—his train was late. He takes his seat and receives from Secretary Pope items for the afternoon. As he calls names of committees the reports are made. Later, on the "elevated" going uptown from Liberty Street, Steinmetz sits next to Calvin W. Rice, of the meetings committee, who takes notes as the president talks. "Now I think this subject is of sufficient importance to be considered at a future meeting and some of the best men to take part are so and so." The sequel comes a month or 2 later.

After dining together at a restaurant, the attractive feature of the day for an out-of-town member, we assemble at 12 West 31st Street. There are informal social greetings, then Steinmetz opens the meeting with a comprehensive, concise, perspective résumé of the topic of the evening with his characteristic encylcopedic perfection. Several members then read short papers presenting various points of view on an important and live topic. General discussion follows. These meetings augmented interest, attendance, and membership, and gave the Institute new life.

Sections; Technical Committees; Branches

A steering committee asked me to be Steinmetz's successor as president of the Institute. I acquiesced with some misgivings as the alternatives seemed to be to continue if possible on the same level or to slump; but I had not counted on the aid and support that others might give.

Steinmetz as president had developed the New York monthly meetings. What was there left to do? I noted that my associates in Pittsburgh who had not attended the Institute meetings had no real appreciation of what was going on and no particular interest in Institute affairs. What could be done to extend interest geographically—to members in Colorado and California? Possibly some type of discussion by correspondence might be devised.

Shortly afterward Secretary Pope said that I undoubtedly would be elected and he had a suggestion—one long cherished and oft repeated without result. Local meetings were being held in Chicago, why not in many other places also? I said it was a fine idea, a means for doing nationally what had been so successful locally in New York. I asked him to work out a plan and we would put it through.

High Voltage Transmission Committee

I recently wrote to Past-President Mershon saying that I regretted that he was not contributing to this anniversary issue of Electrical Engineering and suggesting that he write about the transmission committee. His reply explained why he did not feel able to comply, and continued as follows:

Miami, Florida, March 6, 1934

My dear Scott:

....But I will tell you my recollection of the genesis of the transmission committee.

You were president-elect of the Institute. You asked various persons for criticisms and suggestions for betterment. I was one of those asked. One of the reasons you asked me was, I think, that I had been criticizing the Institute for some time. On your request I amplified my criticisms and made some suggestions. One suggestion was that of special committees to handle special lines of work.

One of the lines of work I suggested as of pressing importance was high voltage transmission.

On becoming president, you arranged for a high voltage transmission committee. That was the first committee of the kind, and, I think, the only one for some years. You appointed me chairman of the committee. I remember that the manner of appointment was such as to imply, to me, at least, perhaps due to a guilty conscience on my part—"Now, you think you are so smart, let's see what you can do." I accepted the appointment and the challenge. You let me pick my committee members, and that helped a lot.

The meetings of the transmission committee were a success from the start. They were better attended than the other Institute meetings. This was due in large part to the fact that we had real discussions. I deliberately adopted the policy of getting discussions rather than papers. The papers I called "Introduction to Discussion." They were short and to the point and provocative of discussion. A man will often let slip out in discussion what he will not put into a paper. The crowd, even those not especially interested in the particular subject, likes a good knock down and drag out—figuratively speaking—fight and that was what they got at the transmission meetings. So they always came back for more.

One evidence of the success of the transmission committee meetings is that the McGraw-Hill Publishing Company obtained from the Institute the right to publish the introduction to discussion and the discussions thereon in a separate volume which they sold as one of their technical publications. Later on, I think, they put out an additional volume covering the further work of the committee. This was the first time—and so far as I know the only one—that anything of this sort happened.

I picked the best authorities in the Institute to write the introductions to discussion. That meant the busiest men. And no matter how busy a man might be, I never had a refusal to my request. This was due in part to the fact that the introductions were short. They usually dealt with a limited portion of some particular phase of transmission. But it was undoubtedly due in part to the fact that a man who wrote an introduction knew the lines would be laid for a vigorous discussion and a full meeting, which would be advertising of the best sort for the author and his particular line of work.

As to the postscript to your letter, I cannot say. But there is no doubt, I think, that the work of the transmission committee had a large part in the development you mention.

With best regards,

Sincerely,

Ralph D. Mershon

My postscript asked whether he agreed with a member who said that the present technical committees were the direct outgrowth of the transmission committee.

My own recollection of the early conversation is definite, but differs in detail from Mershon's. What I think I said was "What is the function of the Institute, what ought it to do?" He replied "I think that long distance transmission has reached a stage which justifies the appointment of a special committee for its consideration." It flashed through my mind that this was something new; committees did not make such studies. I also recalled that data from transmission companies were about to be collected by P. M. Lincoln who had just come from the Niagara Falls Power Company to the Westinghouse technical staff; but I replied at once, "If such a committee is authorized, will you be chairman?"

Now, I do not recall the criticisms of which he speaks. The probability is that he did make them, he usually did. I knew him pretty well—we roomed together in the Amber Club at Pittsburgh, of which Lewis B. Stillwell and Calvert Townley were pioneer members. So I knew Mershon's ability and pertinacity, and also his fine streak of pessimism which made him so interesting; but I confess I had never suspected the "guilty conscience"—that's a new idea. I note also that he himself may let slip out in a letter "what he will not put in a paper."

He did a fine piece of constructive work with the high voltage transmission committee, of which Lincoln of Westinghouse and Blackwell of General Electric were 2 of the members.

Census Curves and Student Branches

When president-elect, I asked T. C. Martin what the Institute ought to be and to do. He was a past-president, editor of *Electrical World*, and as a special agent of the U.S. Census was just completing the first census report on the electrical industry (1902). He said "I don't know what the electrical industry is going to be in the future, but in the past it has been doubling every 5 years." I was stunned; how could we use twice as much electric power, and so soon! The original Niagara Falls power houses were being completed, the elevated railway in New York was electrified, the subway was soon to start, the public utilities were putting in big generators; but if the curve were to continue up, where were the men to come from to operate the accelerating industry—men competent to meet the exacting and increasing responsibilities of electric service—more men, better men. I had taken it for granted that the Institute was to promote the arts and sciences related to the utilization of electricity by adding to knowledge through papers, by their discussion and publication. Here was a new need—men. Should not the Institute develop men as well as ideas? I had been interested in the training of college graduates for one company. Here was a universal need for better graduates. The future men of the industry were in the colleges being trained in theory. Why should not the Institute give them an insight into the problems and practices of the profession, without waiting for a sudden plunge from theory to practice on graduation? So I asked several of my professor friends; they agreed; Professor Ryan at Cornell wrote (condensed) "Bully idea; we've already started."

And that is the way the Institute entered a new field, as an educational agency in the colleges.

Looking Backward

And now when I see a "mountain peak" curve of billions of kilowatthours, I look for the 1902 column—if happily the curve goes back that far. I find that the 1907 ordinate is actually twice as high as 1902; 1912, 4 times; 1917, 8 times; (then the interval for doubling changes from 5 years to 7 years) 1924, 16 times; 1931, 32 times—that is where the curve would have been if we had plotted ahead in 1929; but after a point about 25 times the 1902 unit was reached in 1929 the curve was depressed by the depression. It receded to approximately its value about 2 years earlier and then began to climb again.

Thus Martin's rate of growth based upon progress in the '90's, when output was less than 4 per cent of recent values, held true for about a quarter century after 1902. When the output doubles every 5 years

the total energy during a 5-year period equals the total during all preceding periods. During the 6 years 1924–29 the electric energy used for promoting prosperity was equal to the total consumption during the preceding 40 years.

This geometric rate leads to other interesting conclusions if it be taken as the general law of unimpeded progress. It is a common sport to quote those of the olden times who comment on past progress. The late John R. Freeman relates that the eminent engineer under whom he began to work in the '60's said that the previous 50 years of his life had witnessed the most marvelous advance in all history (it included the locomotive and the telegraph). He was right; for looking back a half century from any point on our geometric curve of progress, the ratio of increase is the same. But the old engineer did not stop with the retrospective view; he added "and there surely will never be another such 50 years!" He died happy—without knowing his indiscretion in making such a prediction. Our predecessors in the fall of 1884, who commented on the marvelous development of electricity in their past, may have observed the same ratio of advance which thrills us in viewing our own past.

In my reconnaissance of Institute possibilities, other members commented on the value of papers and discussions, and one emphasized a high professional standard among members. My 3 planks in a progressive platform came, however, from the snapshot conversations with Pope, Mershon, and Martin; they were Sections, a technical committee, student Branches—concerned with expansion of organization to augment the old time presentation and discussion of papers, the inauguration of group technical activities, and the launching of an educational program.

"Proposed Developments of the Institute"—1903

The first meeting of the board over which I presided as president was called for 2 o'clock instead of 3 in order that the plans I had been making might be reviewed and discussed; but there was so much talk about the routine reports of committees, which I was unable to accelerate, that 6 o'clock came and a proposition to adjourn. I remonstrated and insisted upon 5 minutes for considering future plans. Happily I had written a single page letter to the board saying that the incoming president proposed certain plans which could be put into effect if certain new committees were appointed; then followed a list of half a dozen with their functions. Some one moved the appointments recommended; the motion was carried and we went to dinner. It seems to be the mob psychology of councils and conferences that more can be accomplished in final minutes than preceding hours. At the evening meeting I read a sort of inaugural address on "Proposed Developments of the Institute" which gave a survey of the Institute and electrical activities in general, and elaborated the objectives for which committees had been authorized.

The transmission committee soon launched a notable career which already has been described.

How Sections and Branches Started

The committee on local organizations among members and among students had as chairman Calvin W. Rice. He undertook to prepare a statement with rules for oganization and procedure; but he didn't have it ready, so I undertook to show him how on the evening before copy for the October announcement had to be ready. Until midnight we simply devised questions without getting answers. What should be the Institute regulations and the local by-laws? What headquarters supervision and what the local authority? Should Institute papers be presented locally or should there be local papers, and what should be their status? Finances—should there be dues? Every situation that we thought of ended in interrogation mark. The student enterprise was even more difficult to precrystallize. One alternative was to take months to make by-laws; the other was to start. So we asked members to get together in various places and start meetings, we asked professors to have student meetings; and they did. Years later the experiences gained were a basis for by-laws. We did not know then what I discovered very recently that 2 pages of fine print rules for local meetings had been established many years earlier, and it was lucky we didn't for active effort to meet varying conditions is better than passive compliance with preconceived and restrictive rules.

Classes of Membership

There was a committee on membership It was not functioning well and I found it wasn't sure about the propriety and dignity of really asking people to join a professional society. I replied "Make the Associate grade inclusive and the Member grade exclusive." The committee succeeded in continuing the upward trend that Steinmetz had given to the membership curve.

Type of membership presents a problem. In the summer of 1902 I asked Stillwell as to Institute policies and activities. He replied that a high professional status of members should be sought. Years later I reminded him of this and said my policy had been to bring in large numbers of young men. In the meantime he had been president and I asked him what he had observed as the effect of the expansive policy. He replied "They'll grow."

There was also a committee of older members commissioned to note whether groups with special interests were in danger of flocking by themselves instead of remaining within the Institute organization. There was a feeling that the Electrochemical Society might have been organized as a group within the Institute had its policies been broader. The committee found nothing to recommend. A few years later the Illuminating Engineering Society organized about the time the tungsten

lamp appeared, and again there was regret that it had not been organized within the Institute. Later the radio engineers organized their own institute. Now it is our habit to form a new organization when a group of enthusiastic specialists want to get together. It is said that some civil engineers resented the separate organization of the mechanical engineers in 1880. The electrical engineers organized 4 years later ignoring the fact that Dewey's "Index" makes electrical engineering a subheading under mechanical. We delight in organizing and in exercising group individualism. Have not the electrochemical and the illumination groups done far better as independents? After all most of the technical content of each is nonelectrical. There are, on the other hand, advantages in general coördination of electrical groups.

Developments Not Then Proposed

I note that the "proposed developments" of September 1902 included (1) larger membership, (2) more papers and discussions, (3) local Sections, (4) student Branches, (5) collection of data, (6) support of Library, (7) permanent quarters for the Institute and (8) coöperation with foreign electrical societies. (I had been abroad during the preceding summer.) Although there is no suggestion of a Union Engineering Building or of coöperation with sister engineering societies, these ideas quickly evolved.

Engineering Societies Building, 1902–07

In October the building committee invited me to a dinner meeting at the apartment of the chairman, Calvin W. Rice. This committee previously had made regular monthly reports, somewhat to the effect, as I recall, that they had about $5,000 and that a certain estate might possibly contribute $10,000 more; but the committee was persistent and undaunted.

The afternoon before I started to New York for the committee dinner I talked matters over with Walter M. McFarland, officer of my company, who was experienced in engineering society affairs—principally mechanical and naval. I asked him whether a large building for the 4 principal societies was not feasible, sketching a plan which showed 4 independent entrances and offices, a common auditorium in the rear and library above. He said it was sensible and should be carried out.

After the dinner it was stated that there were 2 questions, first whether the set of plans showing a $50,000 building should be selected or the one on a $200,000 basis; and second, where to get the money. There was free discussion on the first point; but little was said on the second. Then I suggested a larger building for the 4 societies and cited the John Fritz dinner at the founding of the medal a few months earlier as a joint activity that showed what engineers could do when they acted together. Two societies had buildings, one of which was a reconstructed residence, and the other 2 societies had downtown office building headquarters. They were scattered in location and in activities; but my air castle was greeted with silence. I said more and was then told that the societies simply wouldn't pull together, "theoretically it is all right, but practically it won't work." (Friend Martin told me afterward that he added "unless there is some outstanding inducement.") I said that if it was all right theoretically it was good enough for me to talk about. So the meeting adjourned without choosing plans or finding funds.

A little later I was invited as president of the Institute to speak at the 25th anniversary of the Engineers' Club of Philadelphia on the topic "The Engineer of the Twentieth Century." I anticipated a simple task in assembling some plausible platitudes, but as I began to write the theme developed. I found that the great discovery of the Nineteenth Century was *coöperation*, made possible by the engineer; that he was an essential factor in our new industrial and economic life; that engineers themselves did not coöperate; they had created great wealth, but did not have a home; I pictured them in a fine "Capitol of Engineering," active in individual professions, but joined in a congress of engineers for the public interest.

Friend Eglin told me afterward that the electrical president had been invited on his assurances as there had been a question about putting an unknown youngster on a program where the veterans Haswell (of handbook fame) and John Fritz were honor guests and its opening speaker Rear Admiral Melville followed by others of well-known repute. He held

Looking Ahead in 1902

"In the vision of the future may we not discern a reflection of the John Fritz Medal in the larger life of the 20th century engineer? Methinks I see in that reflection the outlines of a magnificent building, the Capitol of American Engineering. Into this home, situated in the metropolis of the nation, are gathered the great engineering societies from their scattered lodgings. Here is a great technical library; here are ample assembly halls and comfortable parlors; here are the headquarters of a score of lesser societies restricted in their scope but affiliated in their work. I see all over the country innumerable local societies and engineering clubs, no longer isolated but joined together into one great combination. I see them affiliated with the national bodies of the several professions—sometimes as local chapters—altogether constituting one great union. There is individual freedom but general coöperation. Representing all the engineering professions and supported by the great union of the national engineering societies, I see an engineering congress giving to engineers a rank consistent with the importance of their work, and increasing the efficiency of the inter-relations among its members. An eminent body, it is powerful in advancing the common interests of engineers, and it represents the engineering profession in its relation to other professions, to pure science, to education, to legislation, to public improvements, and to the general welfare."

From "The Engineer of the Twentieth Century" by Chas. F. Scott, published in A.I.E.E. Trans., v. 20, 1902, p. 305.

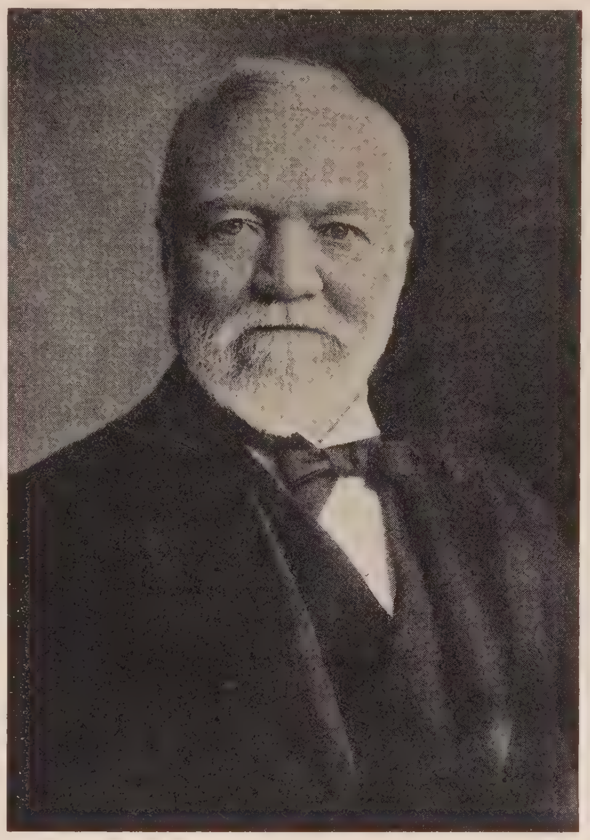
his breath when my imagination took flight in regions of the palpably impossible, if not absurd. The real value of the event, however, was that my earlier suggestion had become a definite ideal.

Carnegie Underwrites Engineering Building

Two months later came the annual dinner of the Institute. Under the chairmanship of Martin it was to be a library dinner. Mr. Carnegie, donor of libraries, who had made a contribution to our library was sought as guest of honor. He declined; again he declined; and again; but the seventh invitation was availing. No wonder that he dubbed Martin "the irrepressible." It was a pleasant dinner; the guest was in happy mood. Martin, toastmaster, was at his best—he hoped that there might be more in store for the library. I, too, had some bait; I spoke of engineers and coöperation and a building as a means of coöperation, and I thanked our guest, patron of libraries, for what he had already done for us; I planned no embarrassment, but pictured pleasant possibilities. In response the "Iron Master" chatted about many things and extolled cooperation as a great principle in which America led Europe. The full record is in the Transactions.

The next morning Mr. Rice, coplanner with Martin, known of the Carnegie household and escort of Mrs. Carnegie to the dinner, telephoned me that Mr. Carnegie wanted us to meet him at his home at 5 o'clock. We were there. Presently he said he was interested in what had been said about a building the evening before, and wanted to know our plans. We said we had none—there was nothing on which to base them. As we sat together on the big sofa, he between us, he said he thought that we 3 Pittsburghers might talk it over together. (Rice then lived in the "Smoky City"); and so we did. Fortunately my colleague knew much more than I about the societies and their resources and Mr. Carnegie's attitudes. At the end of the hour he bid us counsel quietly with a few others and come back when our plans were worked out, and he politely intimated twice more that we had better not come again until we had the plans.

That occurred on Tuesday afternoon. On the following Saturday on returning from golf he found a group of engineers in his library, among them old friends such as John Fritz and Charles Kirchhoff. After friendly greetings he said: "Why, gentlemen, this is very pleasant, but I didn't expect you until you had your plans." "We have them" was the reply—they were on a single typewritten sheet. I recall only the last line "$1,200,000." There was discussion and explanation and then a lull. Presently, he asked "What is to prevent closing this up now?" There being no objection he went to his writing desk and with the ease with which he might have penned a letter of introduction he wrote and read to us with evident pleasure our $1,000,000 valentine (it was February 14, 1903). When he came to the words "Say, one million dollars" his eye twinkled and he moved his hand up and down adding "more or less."



Andrew Carnegie

Building Plans Developed

Things moved fairly smoothly. Committees developed building plans and legal procedure by which several societies could own and operate a building. On one occasion when I arrived in New York, however, I was warned that the "union building" idea was not progressing well as the secret ary of the American Institute of Mining Engineers, as well as one of our own members, were not in line. I had never met Secretary Raymond, but found him in an office building down on John Street, where his own desk and that of an assistant together with several rooms containing the Institute library constituted the headquarters. He said he understood there was to be an amalgamation of libraries in the proposed building and explained how in a simple way his own competent librarian was making their own library useful to their scattered members. When I explained that the whole library arrangement would be left for determination as the several societies might desire he was quite satisfied and expressed much interest in the common building plan. He was a fine man, fascinating in conversation, and profoundly devoted to the upbuilding of the mining institute, of which he had been secretary since 1884. In the lobby of the Engineering Societies Building is a life sized bas-relief presented by his friends bearing the inscription "Rossiter Worthington Raymond, Engineer, Editor, Leader, A Founder of the American Institute of Mining and Metallurgical Engineers."

On inquiry I found that our own disaffected member was Mr. J. J. Carty, leading and influential, chairman of the Institute finance committee while I was president. I had known him well, but never so intimately as when we talked about the building. He foresaw a great future for electrical engineering; he was devoted to the Institute; his ideal was a great electrical building. When I said that such a plan would have to start *de novo*, as I was sure that Mr. Carnegie would not switch from the coöperative idea to a building for a single society, he said "all right then, we'll go ahead."

The following winter the American Society of Civil Engineers voted not to join in accepting the gift. We feared that the gift, inspired by the idea of cooperation, was lost; but we fortified ourselves and went again to 91st Street and 5th Avenue. The facts were stated. With evident disappointment equal to our own he said "Then we can't go ahead, can we?" Then we presented letters from many smaller engineering and scientific societies asking for quarters in the proposed building. "Then they can take the place of the 'civils' and we can go ahead." His smile returned. On March 14, 1904, he wrote a new letter addressed to 3 societies and the Engineers' Club increasing the gift to $1,500,000; building plans had developed that called for that amount.

Carnegie's gift to the engineering societies

Three years later, in April 1907, the Engineering Societies Building having been built "within the appropriation" was dedicated in the presence of Mr. Carnegie. About the same time the adjoining new Engineers' Club was opened. The mining and mechanical and electrical societies occupied their respective floors, other groups additional floors and the 3 libraries were placed together on the 13th floor. From this eminence one could see both rivers; looking south the first high building was the Waldorf-Astoria Hotel of about 14 floors (where is now the Empire State Building) while to the north the only high standing edifice was the *Times* Tower.

There were 3 libraries. Just as confluent rivers of different color may flow together for miles unmixed, so these libraries occupied their separate alcoves and were presided over by their original individual librarians for several years. Then came the joint engineering library, administered for widespread usefulness. This is an excellent example of the practical and psychological difficulties as well as the advantages of their shift from individual to common action.

There was serious question in the minds of some whether the 3 younger and more democratic societies could carry through the building enterprise, paying for the land and meeting operating expense, and on the other hand create a professional standard appropriate to the profession; but they did. Rice and Martin, his successor, as chairmen of the building fund committee raised the nearly $200,000 which was the A.I.E.E. allotment for purchase of the land and the Engineering Societies Building soon came to be recognized as engineering headquarters, often by receiving foreign visitors. In joint American activities the civil engineers often participated.

Fortunately the principle proposed by an early member of the joint building committee had been followed and no action had been taken that would prevent or embarrass the entrance of the American Society of Civil Engineers should they subsequently decide to join the "Founder Societies." Finally, in 1917, they removed from their comfortable house on 57th Street and came to 39th Street, contributing for and taking quarters in additional stories built for them above the Library.

The story of the "Union Engineering Building" as it was termed in a pamphlet in May 1903, had an early chapter as well as the final one related in the preceding paragraphs. The ever alert Martin, who was assistant secretary during the Institute's first year reported a building for scientific and artistic societies as an important need. Later there was a specific and impelling reason why the building committee of 1901 was so persistent, a reason I did not know until the union project was well along. Mr. Dunn in his contribution to this issue describes how Dr. S. S. Wheeler purchased in England the Latimer Clark library of electrical books and presented it to the Institute in 1901. I understood that this was a small collection of very old and rare books. In fact, however, it included practically all electrical books up to the early years of the Institute. Two

large volumes were necessary to catalogue it, the cost of which was covered by Mr. Carnegie's early contribution of nearly $7,000. (Mr. Carnegie matched Dr. Wheeler's investment in the Latimer Clark library.) For this the Institute did Mr. Carnegie honor at the Library Dinner, although the catalogue itself was not completed until years later. In the deed of gift of the Latimer Clark library to the Institute there was a condition that the Institute should provide a fireproof building for it within a certain period. That was the reason why Martin and Rice and Weaver were so tenacious in their quest for a building. The project of an electrical society building had been earlier presented to Mr. Carnegie, as related by Mr. Dunn, but it was on too small a scale to interest him. However, the idea of a building "for you all," which would bring together the various technical societies adjacent to the social Engineers' Club, did meet with his sanction.

Years afterward one who had been closely associated with Mr. Carnegie personally and in the handling of his benefactions said, "That was the most successful of Mr. Carnegie's gifts."

Relations With Other Engineering Societies

The Engineering Societies Building had a significance larger than simply society headquarters and library. Mr. Ambrose Swasey in 1914 consulted with some members of the engineering societies to determine the type of trusteeship that might be established to administer a fund for engineering he purposed to establish. When he asked my views I related an incident that had occurred about 10 years earlier. I was with Charles Wallace Hunt, past-president A.S.M.E., and member of our building committee. We were in his library on the heights of Staten Island. It was evening; leaning back in his chair this idealist and engineer of vision prophesied: "I foresee that the charter which we are now securing which enables the trustees not only to hold and administer the building, but also to receive and administer funds for the advancement of engineering will in the future be found very useful." Thus the agency that the foresight of his longtime friend had provided was adopted by Mr. Swasey in establishing Engineering Foundation for research and "for the advancement in any other manner of the profession of engineering and for the good of mankind." Benjamin Franklin was chagrined that his electrical experiments seemed of "no use to mankind." Swasey established a fund for engineering and "the good of mankind." Standard screw threads and copper wire sizes, bigger and better turbines and generators, were but means to an end. The Institute enrolled a new ideal when its representations with those of the other societies accepted the administration of the Swasey gift to engineering for service.

Engineering Foundation came as a new opportunity; the next chapter in coöperation was brought by necessity—necessity for a single engineering voice of authority. The nation in war needed engineering counsel which separate societies with particular interests could not give. So as an emergency measure Engineering Council was formed with representatives from the principal engineering societies. It functioned well.

After the war it was seen that the common agency of the societies might well be extended in its scope. In the summer of 1919 a conference committee was appointed, the A.I.E.E. members being Calvert Townley, L. T. Robinson, and C. F. Scott. There were 3-day sessions and 2-day sessions and many intermediate meetings of subcommittees in shaping ideals, objectives, functions, and procedure. An incident will interest friends of Townley, who was then our president. On reading the record of the first 3-day session (which I was unable to attend) I discovered a recurring sequence. After a topic received about 8 pages of discussion Townley would move a resolution, which was passed. A new topic then received its 8 pages of discussion when again Townley's name reappeared followed by a resolution which was passed—and the cycle was repeated; again and again he stopped, he listened, he moved.

American Engineering Council

In June there was a preliminary conference of many engineering societies to receive the report and in November 1920 American Engineering Council (at first called Federated American Engineering Societies) was organized by the national mining, mechanical, and electrical engineering societies (the civil engineering society not participating until about 10 years later) and other national and local societies. The following sentences from the constitution indicate the high idealism as to the function of the engineer in our modern life:

> Engineering is the science of controlling the forces and of utilizing the materials of nature for the benefit of man, and the art of organizing and of directing human activities in connection therewith.
>
> As service to others is the expression of the highest motive to which men respond and as duty to contribute to the public welfare demands the best efforts men can put forth, Now, Therefore, the engineering and allied technical societies of the United States of America, through the formation of American Engineering Council realize a long cherished ideal—a comprehensive organization dedicated to the service of the community, state, and nation.
>
> The object of this organization shall be to further the public welfare wherever technical and engineering knowledge and experience are involved, and to consider and act upon matters of common concern to the engineering and allied technical professions.

Herbert Hoover, president of the new adventure in engineering, told the administrative committee that the higher standards of living that our industrial age was affording were counteracted by serious maladjustments—accidents, uncertainty of employment, difficulties between worker and employer. He said the engineer was particularly fitted to undertake the problem of readjustment and proposed that the first task of the new organization be the ascertaining of the facts as to industrial maladjustments. Six months later came the report "Waste in Industry." One thing it showed was the gain possible through simplification and standardization. Mr. Hoover had become familiar with the industrial situation

during the investigation and was then able, as U.S. Secretary of Commerce, to secure simplification and standardization by coöperation of various industrial groups which effected national economies aggregating hundreds of millions of dollars. The Council pioneered a new field, and has a record of fine achievement. The organization has not had the support anticipated, particularly by local societies. Two cents a week in dues seems to counteract the idealism of the average engineer for public service.

In the recent development of the Institute the large number of coöperating relationships during the past decade is notable. Mr. Charlesworth in his history of our organization says we are represented on 27 different bodies; in addition more than half of our Sections are in direct coöperation with local engineering societies.

A.I.E.E. and Education

An organization with which we have very much in common interest (though until quite recently not formal relationship) is the Society for Promotion of Engineering Education, which last year celebrated its 40th anniversary. Many members are common to the educational and to the electrical groups, and the mutual interest of the profession and those who train for it is obvious. Professor D. C. Jackson's account of electrical engineering education in this issue deals with the schools and their significance to the profession.

It happens that the Education society has had 2 electrical professors as president and each initiated an investigation of engineering education. Professor Jackson, pioneer in various educational enterprises, in 1907 (a few months after the dedication of Engineering Societies Building) secured the appointment of a joint committee representing the principal engineering and the education societies whose efforts with Carnegie aid culminated in the report of Dr. C. R. Mann in 1918. Later, in 1923, the proposals of the writer who was then S.P.E.E. president, led to a study of engineering education with Carnegie and other support (including that of the engineering societies and Engineering Foundation), supervised by a board of investigation and coördination of which Professor Jackson has been one of the leading members and the writer was chairman. The director of investigation was Dr. W. E. Wickenden, an electrical educator and A.I.E.E. member. Three years of fact-gathering, to which members of the Institute made a notable contribution, were followed by 12 sessions of the summer school for engineering teachers during 7 seasons, completing the cycle of principal subjects in the engineering curriculum in 1933. The director, after 2 trips to Europe, made a compre-

Engineering Societies' Library as seen from the main entrance (1928)

What Can Be Done

1. Act jointly—pool your interest with sister societies and colleges.

2. Take active measures to guide American youth in its consideration of careers.

3. Create a joint accrediting agency for colleges of engineering.

4. Reëxamine and, if practicable, codify your rules of admission to membership.

5. Through student branches educate students in the history, traditions, ethics, and social functions of the engineering profession.

6. Create joint sanctions for the award of professional degrees, and relate them to terms of admission to professional grades of membership.

7. Take a large share in directing the after-college education of young engineers.

8. Certificate the educational and professional attainments of engineers within the profession.

9. Take measures to create other credentials of educational attainment in addition to college degrees.

10. Do your part, through joint agencies, to promote the corporate welfare of engineering education.

From "What the National Engineering Societies Can Do for Engineering Education" by W. E. Wickenden, published in *Mechanical Engineering*, v. 50, No. 2, 1928, p. 119.

hensive report which indicates the close relationship between engineering schools and professional engineering in the principal European countries and in the United States. There was a supplemental study of noncollegiate technical institutes.

The board of investigation has advocated a larger participation in education by the professional engineering societies. That happily seems about to be realized.

"E. C. P. D."

The latest coöperative venture, Engineers Council for Professional Development (E.C.P.D.) is at least indirectly, a result of Doctor Wickenden's repeated exposition of the responsibilities of the professional societies in the educational field. The new group is composed of the national societies of civil, mining, mechanical, and electrical engineers, the American Institute of Chemical Engineers, the Society for the Promotion of Engineering Education, and the National Council of State Boards of Engineering Examiners (concerned with licensing). Like the Student Branch movement, its principal function is to deal with men, aiding them in preparation for the profession. It is more comprehensive, including precollege guidance and postscholastic development of the engineering graduate in preparation for certification into the profession by his society.

After the foregoing was written I received a letter from Calvin W. Rice whose name appears many times in the early story of library and building and local organizations. He has succeeded in converting electrical enthusiasm into mechanical action; he is now secretary of the American Society of Mechanical Engineers. He writes, April 2, 1934, "It may be of interest to you to see how in '27, 7 years ago, our good friend Wickenden [W. E. Wickenden, now president, Case School of Applied Science] enumerated (in the box) items nearly every one of which are now adopted in the E.C.P.D." The "box" accompanies his lecture on "What the National Societies Can Do for Engineering Education," at the annual meeting of the Society, December 1927, printed in *Mechanical Engineering* (v. 50, No. 2, 1928, p. 119) and republished herewith.

If we class as education the acquiring of knowledge by our members through the reading and discussion of papers and through publications, we agree with an enthusiastic educator who proclaims that the Institute is actually a great educational institution.

Trend in Topics of Institute Papers

That Institute papers have directly aided in solving the problems that have confronted electrical engineers from time to time, is a general understanding in which I have shared. A study of early conditions reveals that this is not always true.

During the first decade of the Institute the acute problem was to make apparatus that would work. Witness the miscellaneous shapes of cut-and-try field magnets of machines. When I entered the Westinghouse factory in 1888 the 2 kw transformer ("40-light" in the nomenclature of the day, *i. e.*, 40 50-watt carbon lamps of 16-candle power) was the largest made. Experimental larger sizes had shown excessive voltage drop and temperature. The largest alternator ("designed for 130 kw and good for 120 kw") had reached the limits of its mechanical design as its armature conductors were laid on a cylindrical core and were (for a while) held in place by band wires which were inadequate for the tangential jerk caused by short circuit or the temperature augmented by eddy currents in the conductors moving through the active field. Then came toothed armatures (one big T-shaped tooth per field pole); then the slotted type. There were many street railway systems in those days each with its own peculiar motor until Lamme's historic No. 3 motor (cylindrical, enclosed, 4 field poles, 4 field coils, slotted armature, machine wound coils, 2 brush arms) became (1892) the prototype of modern motors. There was like struggle for meters and switches and controllers that would operate and keep operating; but the fundamental thing was the machine. A typical larger railway power house had a 500-hp engine belted to a jack shaft with 4 or 5 big pulleys driving 100 kw generators—the largest then available. At the World's Fair in 1893 were 12 duplicate "1000-hp" alternators.

Dynamo and Motor Pioneers Neglected

What guidance did the Institute give to the dynamo and motor pioneers? Under the classification

"dynamos" during the first 5 years are 2 papers; one on a method of testing by Professor Brackett and one on "The Relation between the Cross Section of the Iron in the Armature and Field of a Gramme Dynamo" by Prof. D. C. Jackson. During the next 3 years 2 papers have to do with design, one on compound winding by Louis Bell (Johns Hopkins University, Ph.D.), and one "On the Relation of the Air Gap and the Shape of the Poles to the Performance of Dynamo Electric Machinery" by Prof. H. J. Ryan. During this period the only papers under the classification "motors" which suggest design are "Electric Motor Regulation" by Prof. F. B. Crocker (note the preponderance of professors) and the paper of Dr. S. S. Wheeler (both past-presidents and associated in the Crocker-Wheeler Company) on "The Practical Requirements of Small Motors." Doctor Wheeler says small motors have not been constructed on "the same principles as those of an efficient dynamo machine" of large size. One-tenth horsepower motors were presented; they had a field of "simple horseshoe shape" and showed a departure from ordinary proportions as the Gramme armature was shorter and of larger diameter. Motors of this type were wound for 20-amp and for 10-amp constant current and also for 110-volt constant potential circuits.

Where were other designers with their perplexities and their experiences? Possibly instead of broadcasting their ideas in Institute papers they were preserving them in patent specifications. They were too busy. Note the following paragraph in the discussion of "Distribution of Electricity by Secondary Generators" March 15, 1887:

"Professor Elihu Thomson: This is the first opportunity I have had of meeting the members of the Institute, and I am very glad that I came down. On former occasions I have been entirely too busy and preëngaged to make it convenient to leave the place where we carry on most of our operations."

He then describes his experiment on the reversibility of the Rhumkorff coil (as related in his accompanying contribution to this anniversary issue) and adds that the heavy induced current welded the 2 ends of the wire so that they "actually stuck firmly together. It was with difficulty that I separated them. . . . My recent experiments in welding by electricity are really the outgrowth, as I see it, of that little experiment of the Leyden jar discharge sent through the Rhumkorff coil."

I was surprised to find how little specific technical information is found in the early Institute papers. They were largely descriptive. The nearest approximation to a formula in volumes I to IV of the Transactions is in a chemical determination of the carbon resulting from a combination of acid and sugar in the "Chemistry of the Carbon Filament."

Stanley's Paper on Alternating Currents

There was one paper to which I owe much. Financial reverses in 1887 caused the Baltimore and Ohio Railroad to discontinue the technological school for apprentices in its Mount Clare shops where I was teaching while doing part time graduate work at Johns Hopkins University in mathematics, chemistry, and physics. I visited my old student friend Henry Humphrey who was trying to make incandescent lamps penetrate the darkness of the Hoosac Tunnel. He showed me a little shack at the east portal. "This is the Westinghouse system and the dynamo makes alternating current" he explained; both were new to me. "That is a converter, it has a coil of many turns receiving high voltage and another of few turns giving low voltage." "Why," I replied "that is a Rhumkorff coil backwards."

The only job I could find (after presenting letters from Humphrey in New York) was in Philadelphia. I was so unpromising but persistent a prospect that I was offered a trial opportunity for a week without pay and they would "not charge me for the instruction." I got a job as wireman on the installation of an alternating current lighting plant in the Baldwin Locomotive works. The converter (now called transformer) was a mystery, but I found very helpful my recollection of "self-induction" from the fundamentals of electricity I learned from Professor Mendenhall at Ohio State University during the Spring of 1884 when the Institute was being founded. Also I found useful my personal acquaintance with sine waves gained in making Lissajou curves with a "compound" pendulum in the physics laboratory and also with one I purchased from C. F. Marvin (until recently head of the U. S. Weather Bureau) which he had made in the mechanical laboratory.

I was well prepared by fundamentals and curiosity for a paper (an A.I.E.E. paper I learned afterward) on "Alternating Currents" by William Stanley which I found in *The Electrical World*. The odds and ends of my knowledge and experience fitted into Stanley's simple and clear account—it was rational, satisfying, inspiring. I pictured an author of such erudition as a mature and dignified scientist, such as were pictured with long beards. What was my astonishment a year later when he brought a new machine to Pittsburgh for test (I was wireman for him) to find him young, agile, nervous, enthusiastic, affable and likable. He showed an interest in his young helper which ripened into life long friendship. I surmise that Stanley's paper meant to many others what it meant to me.

But to return to early Institute papers, I find them largely informational and descriptive; there are but few too technical to be understood by the average member. Now and then comes one of outstanding character such as: "A New System of Alternate Current Motors and Transformers" by Nikola Tesla (Trans., v. 5, 1888, p. 308–24); "On the Law of Hysteresis" by C. P. Steinmetz (v. 9, 1892, p. 3–51 and 621–724); and "Impedance" by A. E. Kennelly (v. 10, 1893, p. 175–212).

Classification by Topics; Early and Recent

In the 1900 Handbook the prior Institute papers, 1884–99, are listed under topics which are rearranged in an accompanying table in order of the number of papers included in each (a few papers are listed under more than one heading; *e. g.*, "induction motor" is included under both "motors" and "alternating current practice").

Papers published during the past 5 years that fall under the original topics are listed in the second column of the Table. Over 25 per cent of the topics are credited with no recent papers; among these topics, however, "storage batteries" and "primary batteries" have been discussed as auxiliaries in telephone and telegraph offices, also in papers on the "3-power locomotive"; "polyphase systems" is the title of no recent paper, although over 75 per cent of the 660 papers actually relate to this system, so that instead of 0 one might advocate placing 495 under this topic.

Under several topics the number of papers has increased from 2 to 6 times, *viz.*, "motors," "protection from lightning," "insulation," "power transmission," "telephony," and "welding and annealing." While only 2 papers in the last 5 years appear under the topic of "meters," if those discussing metering systems (such as "telemetering," listed as a new topic) and those treating parts of metering systems (such as "instrument transformers") were counted here, the number would be much larger. In the same way the 25 papers appearing under "power transmission" would be greatly increased if those treating "interconnected systems" and "stability," as well as those dealing with "insulation of power cables" were included under this topic. Many of the 49 recent papers classified under the old topic "alternating current practice" might appear more appropriately under a new heading, "engineering and operating practice."

The first period included 15 years; the second, 5 years; "power transmission" averaged only 1 paper in 3 years in the early period and 5 per year in the later period. Incidentally, the first (1892) and the last (1898) of the early papers on "power transmission" were by Chas. F. Scott.

In the lower portion of the table of A.I.E.E. papers are listed the additional topics necessary for including recent papers, indicating what is new or radically modified. This list is significant. Possibly it should be increased by transfer of some papers now in the first table; for example, recent papers classed under "traction" and referring to "steam railway electrification" might be considered as dealing with radical modifications. Many of the "miscellaneous and theory" papers deal with the theory of unlisted topics. The tables, however, are not presented for microscopic dissection, but for indicating general trends.

A.I.E.E. Papers—1884–99 and 1929–33

Topics in 1884–99 List	Early 1884–99	Recent 1929–33
Alternating current practice	52	49
Miscellaneous and theory	52	90
Traction	30	33
Dynamos	28	33
Motors	21	42
Incandescent lighting	19	5
Units and standards	15	7
Measuring instruments, indicators, etc.	14	22
Protection from lightning, etc.	13	41
Arc lighting	12	0
Telegraphy	11	9
International Electrical Congress of 1893	10	0
Magnetism	10	3
Storage batteries	10	0
Photometry	9	0
Central stations	8	11
Insulation	7	49
Prime movers	7	4
Meters	6	2
Electrolysis	5	4
Mining	5	1
Patents	5	0
Power transmission	5	25
Telephony	5	35
Subterranean work	5	8
Automobiles	4	0
Aluminum	3	1
Polyphase systems	3	0*
Primary batteries	3	0
Railway train lighting	3	0
Resonance	3	3
Welding and annealing	3	19
Impedance	1	0
Therapeutics	1	1
Mean per year	26	100

Additional Topics in Papers of the Last 5 Years (1929–34) Which Are New or Radically Modified Since 1900	
Interconnected power systems and stability	24
A-C distribution networks and relays	15
Automatic control of frequency and voltage regulation	10
Automatic stations, telemetering, and supervisory control	18
Transformers—tap-changing under load and surge-proof	18
Impulse voltage—generation, measurement and testing	11
Mercury arc rectifiers and inverters	12
Relays—high speed distance type	4
Oil circuit breakers—theory, design, and testing	12
Oscillographs—cathode-ray and portable automatic	6
New types of fuses, lightning arresters, protective gaps, arcing horns, switchgear, etc.	13
Inductive coördination between power and telephone plant	4
Radiotelephony and aeronautical communication	19
Elimination of noise and sound analyses	12
Vehicular traffic signals, railway signaling, and automatic train control	11
Synchronous clocks	1
Television—2 way	1
Electronic applications	11
Electrical equipment for smoke abatement	2
Electric shock	2
Network analyzers	1
Applications to oil well drilling	2
Electric furnaces	1
Electric house heating	2
Mean per year (additional topics)	43
Mean per year (all topics)	143

*No papers were on the subject of "Polyphase Systems;" yet over 75 per cent of the papers involve theory and apparatus used in connection with polyphase systems

Transactions and Other Records; N.E.L.A.

Presumably many early papers were voluntary contributions by authors while others were requested by the committee responsible for providing a program. Later came more definite planning of programs, as in Steinmetz' presidency and in later years when the convention programs are largely sponsored by the technical committees.

It sometimes is assumed that the Institute Transactions present a complete moving picture record of electrical engineering. This is only partly true; the Transactions constitute an invaluable but not a complete record. The electrical press, including the *Electrical World*, the *Electric Journal*, the *General Electric Review*, publications of the Bell Telephone System, "proceedings" of related societies in the fields of electrochemistry, illumination, welding, radio, and education as well as certain papers presented to the A.S.C.E. and A.S.M.E. are needed to complete the record; nor can patent specifications, interferences, and litigation be omitted for they contain much of historic value.

Steinmetz great paper on complex quantities was

presented to the Electrical Congress of 1893. This congress, as well as that of 1904, was sponsored by the A.I.E.E. and the "Proceedings" were printed under our auspices but as independent volumes. It seemed to me in 1904, and I am of the same opinion now, that the proceedings of such congresses might well have appeared as supplemental volumes of our TRANSACTIONS thereby placing there and in our indexes much worthwhile material.

The National Electric Light Association received papers that should have been ours, such as Lamme's classic on the induction motor (1897). The technical committees of that association have done a great piece of work. Engineers of public utilities were given a Herculean task of installing apparatus and providing systems to meet growing demands. Previous rapid growth had been accelerated during the war period and the output during the final war year 1918 is shown on a widely published curve as 34 billion kilowatthours. By 1929 this had increased nearly threefold to 93 billion; nor did this involve mere duplication of equipment. Scientific research and engineering development were producing new apparatus for generation and transmission and control while "super power" and interconnection were imposing new problems in design and operation. Engineers of the utilities were urged to quick action by the endeavor of their managers to meet the public demand for electric power; and the criticism of utility financing and management cannot be attributed to failure of engineers to meet their gigantic problems.

But what of their relations to the Institute? It seemed to me in 1902 that the N.E.L.A. was taking up many technical problems that the A.I.E.E. had been handling; and under the vigorous stimulation of its president, H. L. Doherty, it was doing a real job. Recently Mr. E. C. Stone of the Duquesne Light Company (Pittsburgh, Pa.), for several years chairman of the technical committees of the N.E.L.A., stated the relationship thus:

"Our problems were urgent; as public utility engineers we got together to solve them; we were largely A.I.E.E. members; but when we had something new and outstanding we wanted it to appear as an Institute paper, on account of the prestige and standing of the Institute."

This sentiment, if my observation is correct, is widespread.

The Institute Functioning as an Organization

When in December last I accepted a part in writing the history of the Institute it seemed to me that the influence and achievements of its members acting as an organized group in contrast to what they might have accomplished as individuals would be a fruitful line of inquiry.

The trend toward organization has been general. When the Institute was organized, engineering and technical societies were few; now they are legion. Industry and business have been completely revolutionized by consolidations. I have just noted an article in *Cassier's Magazine*, October 1901, on "Some Recent Industrial Consolidations" which lists great combinations or "trusts" in steel, locomotives, agricultural implements, shipbuilding, machinery (Allis-Chalmers Company), tin cans, and watches, also "carpet, packing, egg, and cereal consolidations. . . . Lighting and street railroad companies all over the country . . . oil-field companies, coal companies, and electric power organizations are being amalgamated from the Atlantic to the Pacific. . . . Each week and month add a chapter to the remarkable industrial revolution." A companion article deals with trade combinations in Great Britain and on the Continent.

The economies of large scale physical operation—in large measure the development of engineers who provided power and machinery—forced the small factory, often developed by the individual who became owner, manager, and expert, to shut down or to merge with others.

In electrical manufacturing there were in the '80's many makers of arc lighting equipment and incandescent generators and lamps and railway motors and various electrical equipment and accessories. Consolidations came, notably the General Electric Company in 1892, as described in Professor Thomson's accompanying article, which continued the absorption of other companies, such as those of Sprague and Stanley. The Westinghouse Electric and Manufacturing Company in 1920 was a composite of a score of prior organizations, as shown in Colonel Prout's biography of George Westinghouse.

Research and design shifted from individuals to groups. A generator or a transformer or control equipment is now the product of many experts. Sprague's Richmond car and his early multiple unit train control were probably about $99^{44}/_{100}$ per cent pure Sprague; but the monster Pennsylvania single-phase locomotive is the product of the combined experience and technical acumen of scores of Westinghouse and General Electric experts collaborating in the design of motors and controls, and coöperating with engineers of the Pennsylvania Railroad and the Baldwin Locomotive Works. The scale of activities

Origin of Papers Published in the A.I.E.E. Transactions During the Past 3 Years (1931-33)

Occupational Classification of Authorship	No. Papers	Percentage
Electrical manufacturers	176	40.0
Central stations	60	13.6
Universities	55	12.5
Committees	45	10.2
Communication companies	28	6.4
Railways	12	2.7
Industrial	11	2.5
Consulting engineers	10	2 3
Government	3	
Unattached	2	
Jointly by manufacturers and central stations	15	3.4
Jointly by communication companies and central station	6	.1
Jointly by universities and central stations	3	
Jointly by universities and manufacturers	2	
Jointly by manufacturers and railways	3	
Jointly by competitive manufacturers	4	
Jointly by communication companies and manufacturers	2	
Jointly by consulting engineers and central stations	1	
Total	438	

has passed the capability of the individual; group action is essential.

Changing Industrial Environment

These snapshots during recent decades picture the changing industrial environment of our Institute. We cannot pause here to indicate the potency of electric power and processes in shaping large scale production nor the significance of the telephone as the high speed tool of modern business. We may consider for a moment, however, the electrical developments that preceded and made possible large scale operation in electric power. As illustration note the Hartford Electric Light Company and its progressive upbuilding under the leadership of its president, A. C. Dunham (donor of the Dunham Electrical Laboratory at Yale University). About 1897 its station supplied arc lighting on 10-amp and on 6.6-amp circuits, incandescent lighting on 3-wire d-c and 1,100-volt a-c circuits, and power on 500-volt d-c circuits. There were 24 belt-driven generators, aggregating a trifle over 1,000 kw supplying their loads by 21 separate and independent circuits which could not be put in parallel.

Then came polyphase alternating current, at first from water power, then (1901) from the pioneer steam turbine in an American central station, Westinghouse-Parsons (Parsons applied for and received his English patent on the turbine in our natal year, 1884), and now from a General Electric mercury boiler and turbine. There is interconnection with surrounding plants, and even Niagara power by intermediate interchange has served Connecticut in an emergency. The key to it all is the polyphase system, announced in Tesla's Institute paper in 1888; demonstrated on a large scale at the Chicago World's Fair in 1893; put into large scale service at Niagara in 1895; and now providing practically all of our world-wide electric power service. One day at the World's Fair Dr. Louis Duncan, then president of the A.I.E.E., said "Scott, some of us want to discuss power transmission at the electrical congress tomorrow afternoon. Can't you describe the Westinghouse polyphase exhibit?" My account appears in the "Proceedings" of the congress published by the Institute. Several years later in presenting a paper "Niagara Power" to the Engineers' Club in Philadelphia I used a diagram showing the varieties of a-c and d-c services at fixed and varying and adjustable voltages that were being supplied locally and at Buffalo from a single set of bus bars. Mr. E. D. Adams reproduced the diagram in his book "Niagara Power"—very commonplace now, but in the middle '90's a revolution that made large scale electric power possible and enabled electricity to become an active agency in large scale coöperation.

The Institute itself, rejoicing in the membership of 279 reported by the national secretary at the end of the first year (although Secretary Pope reports a "total paying membership" of 98 as of May 17, 1887, 322 in 1888, and 742 in 1893; Trans., v. 10, 1893, p. 536) and holding annual meetings at which 11 papers were presented in 1884, 5 in 1885, and 6 in 1886, has grown in membership and activities to the organization it is today. The story of this development is interestingly related in the accompanying article by Past-President Charlesworth. One is impressed by the Institute's territorial expansion—61 Sections and 113 Student Branches; by its score of technical committees; by the 30 or more representations in 27 other engineering and scientific groups; and by the considerable but overloaded operating staff.

Standardization; Kennelly and Skinner

Some of the activities which are essentially those of a group and not possible by independent individuals merit special comment. Standardization is an outstanding professional activity. The contributions by past-presidents Kennelly and Skinner show an amazing development. The Institute was entering its sixth year when it took the first step by recommending the name "henry" for the unit of induction. A few other recommendations as to nomenclature and scientific units and the adoption of a standard wiring table (in which the fixing of the Matthiessen value of copper resistance was a crucial point) was nearly all until the "committee on standardization" came in 1898. It dealt with engineering and technology, and continually expanded its scope. Then about 1920 the work was extended to production and manufacture and later the American Standards Association evolved largely under A.I.E.E. leadership. All this provides scientific, technical, and industrial foundation upon which to build.

These contributions of past-presidents Kennelly and Skinner provoke personal reminiscence. Reading between the lines Kennelly's contribution is autobiographical. It portrays his clarity of thinking and expression; his aptitude and interest in scientific nomenclature, the language that enables engineers to understand one another; his continued interest since his chairmanship of the Institute's initial committee on units and standards. I really came to know him when I was a member of the standards committee and he was secretary of that committee. One incident impressed me greatly—the facility with which he instantly condensed my rambling paragraph into this: "Note. The following definitions and classifications are intended to be practically descriptive and not scientifically rigid." About the same time, some 30 years ago, I was a member of another committee of which Skinner was secretary; it was a works committee on purchasing department specifications at the Westinghouse company; it included representatives of purchasing, engineering, testing, and manufacturing departments of the company. The problem was to prepare specifications acceptable to all departments and to prospective bidders for wire, sheet iron, tool steel, shafts, insulating materials, and what not. The secretary was the focal point for objections from all concerned and it was his function to draft and redraft specifications until they were practical and adequate and received approval. In this he acquired technical and diplomatic experience which stood him in good stead in the battles royal of national groups later on.

Technical Problems

Group attack on technical problems is a powerful agency. The power transmission committee brought together at the Niagara Falls convention in 1903 over 60 interested members who represented, as I noted at the time, practically every transmission company from Montreal to Los Angeles, including cities with underground cables; and there were experts from manufacturing companies, from laboratories, and from colleges. The method of discussion is described by Past-President Mershon. This forum of operating men and designers and experts through successive years laid the basis for the transmission networks that cover the country.

The Institute committees provide a technical meeting place of engineers of commercial competitors. In one instance engineers of manufacturing and operating companies held conferences that finally culminated in tests on 4 large turbine generator units after installation for determination of safe temperature limits. Similarly investigations are under way directed to the standardization of test methods and performance limits to establish the surge voltage strength of transformers.

Again, the comprehensive and inclusive problem of insulation coördination between the various parts of a transmission system is under consideration by several of our committees.

Complex problems require coördinated handling. In early power transmission by constant current at variable voltage (practically the only method considered in Kapp's "Electrical Transmission of Energy," 1888) and by alternating current as the synchronous motor at Telluride in 1891, the transmission wires connected one generator to one motor. Individual machines were connected together in the simplest ways. However, modern interconnected transmission and distribution systems are not simple assemblages of independent units; the characteristics of each of the circuits must be coördinated with the whole to secure operating tranquility. Hence, designers of the various elements and operating engineers, not of one but of many systems, must plan together. Mr. Fortescue points out that the presentation of symmetrical coördinates and of system stabilization to the Institute secured a wide audience of the many concerned. Furthermore, a new idea (usually commended by one's associates) receives a stimulating diagnosis when it encounters the queries of commercial rivals who aim to bring out the weak points or omissions. Improvement is likely to follow, by the originator or his rivals.

A.I.E.E. a Voluntary Organization

As problems become comprehensive and involved, the Institute therefore provides a forum, where designers and operators, irrespective of race, color, or conditions of servitude can meet on common ground, and where quality is the predominating criterion.

The Institute is a voluntary organization; it cannot compel its members nor has it authority to enforce its recommendations or its standards. It depends on the freely given service of its members and on the prestige of its standing as a professional body. I note a sort of reverential regard by our members for something intangible—not for committees or boards or individuals, but for "The Institute"; and its members jealously guard its reputation from commercial or unprofessional taint.

In their Institute activities electrical engineers have learned to work together. Although of diversified interests—technical and commercial—they have coöperated to build their profession and their industry. There have been rivalries and controversies, some quite vigorous, as in several "battles of systems"; but in general in a wholesome spirit of give and take. We have sought to find a better way in a practical spirit of optimistic progress. Our contentions are clarifying and we emerge on a higher plane.

The ability to work together which electrical engineers have attained in the Institute is a quality sorely needed elsewhere. Present forward looking readjustments in industry and business demand a shift from the excesses of ruthless individualism to rational coördination. The threatening difficulty is in getting industry and business to do what engineers have been doing in their Institute work. Possibly the great thing that the Institute has achieved by group action is a demonstration of the methods and results of large scale voluntary coöperation.

Institute Service to Its Members "Social Intercourse"

The acquiring and transmission of knowledge is essential to progress. The great accomplishment of the Institute is the publication of several thousand contributions on 50,000 and more pages of its Transactions which have been distributed to a membership that has increased more than a hundredfold. Papers are scrutinized by experts before acceptance, and are refined and amplified by discussion—a process stimulating to authors and protective to readers. A problem past, present, and probably persisting, is to meet the needs of a varied membership. Our society is not exclusively scientific and professional; it represents an industry; it is made up largely of "associates"; it enrolls students. A technical committee rejoices when a super expert edifies his expert group by symbols or terms that are jargon to the uninitiated. Possibly any one of a majority of our papers is of real significance to 10 per cent or less of our members, which attests value or otherwise according to one's point of view; but our publication policy aims by wide variety to provide for every taste: Note the recently inaugurated series of scientific expositions for younger and general readers, supplementing the educational objectives of Student Branches and the Engineers' Council for Professional Development. If any group feels neglected it may well question whether its own activity is not at low ebb.

I was surprised to note the order in which the

rules adopted May 13, 1884 list the methods by which the new Institute was to accomplish its objectives: it is (1) by social intercourse, (2) by papers. This seems to presage the order of precedence at our annual conventions in which the award of the Mershon Trophy and prizes for golf and tennis arouse greater general interest than awards for best papers. I've been asking myself and others during the past few months, just what really is the outstanding feature of the Institute? I am seeing some things in new perspective. What have I gotten out of the Institute? "Social intercourse" is not limited to banquets and evening clothes, but includes committee meetings and shirt sleeves, golf courses and tennis rackets. It is seeing men, hearing them, meeting them, knowing them, catching their spirit, cherishing their friendships that count. I find that I have met every president except the first and I learned of him quite early, as "Norvin Green, president" was conspicuous on Western Union Telegraph blanks. In a few cases—only 3, Pope, Weston, Houston—the meeting was incidental or brief; with nearly all of the others the association has continued through the years. I met Anthony only a few times, and Bell I think but once; but as it fell to my lot to present to him the John Fritz Medal during the dedication exercises of the Engineering Societies Building it made a deep impression. (I did see him again in 1915 at the public demonstration in our auditorium of the transcontinental telephone, when his original telephone was exhibited and employed by him in talking with San Francisco.) At the dedication in 1907 he was well along in years, but so simple and gentle and kindly and appreciative! As I write these words, they call to mind another great figure. It had been my privilege a few years earlier to visit Lord Kelvin in his home in London. In my memory, Bell and Kelvin are very much alike.

I don't remember what it was that took so much time in our board meetings, but I do remember the men and their ways; and in the fascinating constructive work on the Engineering Societies Building Committee and American Engineering Council it has been a great privilege to work with the leaders in the other societies. Yes, to me "social intercourse" may even take first place, for it has brought me friends and activities that have enriched my life.

Inspiration by Association

President Whitehead finds one of the Institute's best fruits to be "the power which its meetings and publications have of attracting aspiring young men and maintaining their allegiance. This appeal to young men has been the greatest asset and strength of the Institute." Not scientific knowledge, but an appeal "inherent in the Institute."

Past-President Rice speaking of the early years says our "organization formed a nucleus which steadily drew to itself the earnest electrical workers in all parts of the country." What resulted was "the inspiration that comes only from association of people of similar interests and of like minds."

The Institute has been characterized as a great educational institution. The college, too, has its "papers," its lectures, and discussions, its technical laboratories, and is operated with carefully balanced curricula; but what the fortunate student values most in later years is the atmosphere of the place, the methods, the personality, the ideals, the inspiration of his teachers, and the association with fellow students "of similar interests and of like minds." The real things in school, in Institute, in life are intangible, inspirational, spiritual.

Fortunate will be this anniversary occasion if we can show the way we have come and point the way onward in effective service "for the good of mankind" which may inspire our young men to lead on.

Finale

In planning for the fiftieth anniversary of the Institute the committee assigned a particular part to me because of my long personal participation in Institute affairs. I joined the Institute in 1892. I was elected a director in 1895 and have been officer, representative, or committee member continuously since that time. Perhaps Doctor Kennelly alone has a longer record of service.

Possibly I have been unduly responsive to the suggestion that there be ample embellishment by personal reminiscence. The perusal of old time records, the reading of past-presidential contributions of wide variety, personal reminiscing with old timers and with others have awakened interesting recollections and have given me new viewpoints and a perspective of various happenings; these now present a significance which one does not recognize when enmeshed in details.

My romancing excursion into the past is brought to an abrupt close by telegraphic demand of the Editor for copy. I close with a profound sense of inadequacy of my story as a "history" and a feeling that the future may discover that the rôle of the Institute in our changing civilization has a significance we do not realize.

In the fabric of electrical engineering the long scientific threads of the warp are bound together and given pattern and utility by cross threads which are the life achievements of individuals. As the loom keeps weaving through the years new threads of scientific knowledge are added to the old, and new workers contributing woof of finer quality enrich the beauty and enhance the utility of the product.

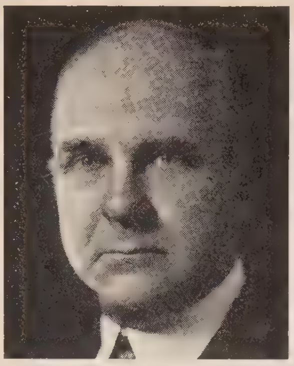
Chas F Scott

The Institute's Organization

By H. P. Charlesworth, President A.I.E.E. 1932–33

How the Institute's organization has grown from its early modest beginning to meet the widely diversified needs of a rapidly expanding membership is reviewed briefly in this article. One cannot review the history of the Institute's organization "without being impressed with the flexibility it has shown in adapting itself to changing conditions, and we may be confident that this will continue . . . in the future."

ON THIS the occasion of the fiftieth anniversary of the Institute, it is my privilege to review briefly what has taken place over the years past with respect to its organization. To this end, it will be interesting, I believe, to look back at its early form and consider how it has expanded from a very modest beginning to meet effectively the diversified requirements of the various activities that naturally developed in an institution associated with such a rapidly growing industry.



As Professor Scott tells us in his historical review, the American Institute of Electrical Engineers came into being at a meeting in New York City on May 13, 1884. While the initial membership cannot be stated with exactness, as the early records are incomplete, the first rolls carried the names of many who were destined to be leaders in the electrical arts over a long period of years, including Thomas A. Edison, Alexander Graham Bell, Elihu Thomson, Edwin J. Houston, Edward Weston, Theodore N. Vail, Charles F. Brush, Elmer A. Sperry, and Norvin Green. They were quickly followed into membership in the new organization by other men whose names are associated with outstanding contributions to the early development of the art.

General Organization

Management of the affairs of the Institute was placed in the hands of a council composed originally of a president, 6 vice-presidents, 12 managers, a secretary, and a treasurer. In 1901 the name of this managing body was changed to "board of directors." Its makeup, through successive changes, has been modified slightly so that it now includes 10 vice-presidents, instead of 6, and 2 junior past-presidents. The national secretary acts as secretary of the board without vote. In the interim between meetings of the board, matters requiring attention are passed on by an executive committee of 7 members.

While the term of the national secretary is one year, through repeated election and reappointment, he has been in fact a continuing executive officer of the Institute, and the development of the Institute's activities has been influenced in large measure by the wisdom and vision of the men who have occupied this office. Of the 4 national secretaries who have served the Institute, 2 have covered 47 of the Institute's 50 years.

The first secretary, Dr. Nathaniel S. Keith, under whose leadership the original group that formed the Institute was brought together, served only for the first year. For the next 27 years until his retirement in 1911, it was the Institute's good fortune to have the services of Mr. R. W. Pope, a charter member, in this office. His executive ability and enthusiasm, and his wise, discriminating counsel contributed greatly to the Institute's progress during his period of service from a modest beginning to a large and effective organization. The traditions established by Mr. Pope were capably sustained over the next 20 years by his successor, Mr. F. L. Hutchinson, who brought to the office a rare statesmanship and a detailed knowledge of Institute affairs gained in a long experience as assistant secretary. In the difficult years since Mr. Hutchinson's death in 1932, this office has been filled very ably by Mr. H. H. Henline, who also had long experience as assistant secretary before assuming his present duties.

Growth of the staff working under the national secretary at Institute headquarters is illustrative of the development of the Institute. Starting with only part time of the secretary alone, later supplemented by some stenographic help, the staff grew to a force of 35 men and women at its peak in 1931. In the course of the depression years it has been reduced to 25. The growth of the staff reflects the increase both in the amount and in the variety of services performed. An important division of the present organization is the editorial division which edits and publishes Electrical Engineering and Transactions of the Institute, under the direction of Mr. G. Ross Henninger. Advertising in Electrical Engineering is under the direction of Mr. C. A. Graef. Other important work is represented by the committee secretaries, Mr. H. E. Farrer serving as secretary of the standards committee and the board of examiners and Mr. C. S. Rich serving as secretary of the technical program committee. The business office and general office management work constitutes the largest group and is under the direction of Mr. F. A. Norris. The sustained loyalty of the staff to the ideals of the Institute always has been one of the Institute's great assets.

Geographical Divisions

While from the beginning the Institute was a national organization, technical activities at first centered a good deal about New York City. Except for the first regular technical meeting, which was held in Philadelphia on October 7 and 8, 1884, all of the meetings for the first 5 years were held in New York. After that there were occasional meetings in other cities, Boston (1890 and 1899), Chicago (1892), Philadelphia (1894), Niagara Falls (1895), Eliot, Maine (1897), and Omaha (1898). Minutes of the early meetings show that the officers were increasingly aware of the geographical problems presented by the far-flung distribution of the growing membership. There were repeated discussions dealing with measures for enabling the active participation of distant members in the Institute's affairs and for increasing the usefulness of the Institute to them. Mr. Pope was a constant champion of these distant members. Only a few days after the third anniversary of the Institute, he offered the following suggestion:

> "It has come to my notice that there is a field for the establishment of branches of the Institute in some of the larger cities.... The electrical interests in other cities are very large and with a little assistance and advice, perhaps, and by providing in the rules for the establishment of such branches, I think some good may be accomplished in that direction...."

Again in 1893, Mr. Pope called attention to the increasing proportion of the membership residing outside of the vicinity of New York. Shortly afterward a plan was authorized by which, upon petition of 20 members, meetings might be held in any city at the same time as those held in New York, the same papers being read and discussed simultaneously at all meetings. Many meetings of this kind were held in Chicago; but the practice was not generally followed elsewhere until 1902, when independent local meetings and activities became a prominent feature of Institute work.

At that time Mr. Pope discussed this matter with Dr. Charles F. Scott, then president-elect, and he later appointed a committee on local organizations to promote local meetings. As a result, plans were approved for the organization of local groups of members in geographical Sections. Also, at the suggestion of President Scott, groups of engineering students in universities and technical schools were organized into Branches. This establishment of Institute Sections and Branches was a move of fundamental importance in the Institute organization. The members of both Sections and Branches multiplied quickly and, with this, began the really rapid growth in Institute membership.

The importance of this step is illustrated by the fact that there are today 61 Sections and 113 Student Branches. The Sections cover the portions of the United States, Canada, and Mexico that include approximately 85 per cent of the Institute members, who are automatically members of the Sections in which they reside. The expenses of the Sections are borne by the Institute through a remission of a portion of the dues of Section members and by other appropriations. The Sections possess a high degree of autonomy, each having its own by-laws, electing its own officers, and conducting its own meetings.

Student Branches are in each case conducted with the general advice of a counselor appointed by the president of the Institute, and are quite autonomous in character. They provide a means by which, even during his college years, the student may become associated with his profession. The student members receive a subscription to Electrical Engineering and favorable terms of admission to the Institute upon completion of their courses.

The very important part that the Sections and Branches have in the life of the Institute, through frequent meetings for the presentation and discussion of papers, is illustrated by the fact that in the year ending April 30, 1932, they sponsored a total of 1,632 meetings having a total attendance of 160,000. Studies are constantly being made of means to strengthen the Sections and Branches and increase the scope of their already wide activities. This sectional organization has been of inestimable help in providing broader opportunities for the development of engineers through the exchange of experience and through inspiring contacts with eminent members of the profession and in the general development of the electrical arts and of the Institute. Provision is made for a conference of delegates of the Sections and Branches at each summer convention; out of these conferences have come many suggestions of value for carrying on and broadening the activities of the Institute.

Always on the alert to adjust the organization to changing conditions, the board of directors in 1919 appointed a committee on development to consider, among other things, ways and means of increasing the service rendered by the Institute to its members. As a result of the committee's recommendations in order to provide a closer relationship between the Institute and its Sections and Branches, the area of the United States and Canada covered by the Institute was divided into 10 districts and the number of vice-presidents was increased to 10, one for each of the districts. These district organizations keep in very close contact with the Sections and Branches in their areas and form a needed link in the geographical organization of the Institute for the most effective coördination and extension of its activities.

Committee Organization

It is interesting to note that the committee organization which is such an important feature of the Institute's activities began very early in the Institute's history. At the second meeting of the council on June 3, 1884, the following standing committees were appointed:

Dynamo electric machines
Telephones
Telegraph
Arc lamps
Incandescent lamps
Prime motors and transmission of power
Electric railways and signals

Underground and submarine cable work
Electrochemistry and metallurgy
Voltaic batteries, galvanometers, and measurements
Secondary batteries

This list is significant as indicating the scope of the art and its recognized divisions at that time and as representing an early precedent for our present technical committees.

In these first days there was no recognition of specific committees in the rules of the Institute and, generally speaking, these committees like the other early committees were short lived, the committee organization changing from year to year. However, prior to 1900 there had emerged certain committees of a permanent character, including the committee on meetings and papers, committee on membership, and board of examiners. Of interest also among the committees of the early days are the committee on finance, building and permanent quarters, the editing and library committee, the committee on standardization, and the committee on units and standards.

In any association of the character of the Institute, committees of members are sure to carry a very important part of the activities, and it is not surprising that with growth there should have developed as a permanent part of the organization, a large number of committees: specifically, 18 technical committees, each dealing with some branch of the electrical art, and 25 general committees. Beginning with the transmission committee appointed by President Scott in 1902, the technical committees have increased in number and in range of activities to include the discussion and the stimulation of all branches of electrical development. Of the general committees, one group deals with questions involving management, including the executive committee, committee on coördination of Institute activities, board of examiners, finance committee, headquarters committee, the committees on membership, transfers, publications, and technical program. Some of these committees deal with general questions of policy, including the Institute policy committee, committee on legislation affecting the engineering profession, and the committee on code of principles of professional conduct. Other committees deal with relations to other organizations and with the award of medals and prizes. Other important committees are those devoted to the activities of Sections and of Student Branches.

It is naturally out of the question in this brief review to discuss or even to outline the scope of all of these numerous committees. This important phase of the Institute's activities and the way in which the organization has developed and been modified to meet changing conditions is well illustrated by a brief discussion of the form of organization devoted to one of these important matters, namely, standardizing work. The first committee dealing with standardization was appointed in 1889 to prepare a table of standard wire sizes. Subsequent temporary committees from time to time carried out the fundamental work of establishing standards of performance for electrical machinery, leading to the establishment in 1907 of a permanent standards commmittee to carry on this work. This committee developed rapidly in the scope and importance of its work. Moreover, with the growing interest of other organizations in engineering standards, the Institute took the lead in 1918 in promoting the organization of the American Engineering Standards Committee (now the American Standards Association) to bring about the closer coördination of the standard work of various organizations. The development of the A.S.A. has led to the organization in 1931 of the Electrical Standards Committee, in which the members of the A.S.A. most directly involved in electrical standards closely coöperate, and to whose auspices have been transferred a considerable part of the work formerly done solely under the auspices of the A.I.E.E. standards committee.

Another phase of this activity is the relation of the Institute to international standardization. From the first, the Institute took an important part in international electrical congresses and in 1904 the International Electrical Congress in St. Louis was held under its auspices. An outcome of this congress was the International Electrotechnical Commission, which was represented in this country by a committee of the Institute established in 1907. Subsequently, the membership of this committee was broadened to include representatives of other interested organizations and in 1931 its sponsorship was transferred to American Standards Association.

These variations in organization arrangements illustrate the traditional point of view of the Institute to be ready to take the initiative in undertaking new activities when an evident need develops, yet retaining a flexibility for the modification of these arrangements and closer coöperation with other organizations as this becomes desirable.

Relations With Other Organizations

Realizing that for the broad development of engineering, and to take a proper place in the general activities of the country, it is not sufficient for the electrical engineer to work solely with those of his own group, the coöperation of the Institute with numerous other organizations always has been recognized as desirable. This is illustrated by many other features of the organization, it being represented on 27 engineering, scientific, and research bodies, several of which it aided in founding; through these, it takes part in numerous activities involving a wide range of engineering, scientific, and research projects of public importance. In the American Engineering Council it coöperates with representatives of 20 engineering organizations in the study of public questions that are largely engineering in their nature or are of particular interest to the engineer. With 3 other national engineering societies, the American Society of Mechanical Engineers, the American Society of Mining and Metallurgical Engineers, and the American Society of Civil Engineers, it appoints representatives who together constitute the United Engineering Trustees, Inc., an organization formed for the purpose of holding title to and administering the Engineering Society Building, a number of endowment funds, and other property.

This bringing together under one roof of the largest national engineering societies has been an important factor in stimulating the development of close cooperative relations between them. This joint organization also maintains the Engineering Societies Library, a free public reference library of more than 140,000 volumes, including many rare and valuable books. Through this relationship and also by direct appointment, the Institute participates in the activities of the Engineering Foundation, which was founded in 1914 by Ambrose Swasey "for the furtherance of research in science and in engineering and for the advancement in any other manner of the profession of engineering and for the good of mankind."

Others of the 27 organizations upon which the Institute is represented might be mentioned, such as the National Research Council, the American Association for the Advancement of Science, and the Engineers' Council for Professional Development. However, sufficient has been said, I believe, to illustrate fully the breadth and importance of these relations with other organizations.

As to the Future

Embarking on the second half of the Institute's century of progress we are witnessing a time of rapidly changing conditions affecting both the individual and society as a whole. It is impossible, of course, to predict what further changes in our form of structure may develop as we enter upon the years ahead. However, one cannot review the history of the Institute's organization as we have just done, without being impressed with the flexibility it has shown in adapting itself to changing conditions, and we may be confident that this will continue to characterize the Institute in the future. As social, governmental, and economic conditions continue to change we may be assured that under the continued wise direction of its officers, its board of directors, and those in charge of the various geographical subdivisions and committees, the Institute's organization will be quickly modified and expanded to meet each new demand and to take advantage of each new opportunity for service.

A Group in Attendance at Past-President's Luncheon, Swampscott, Mass., June 28, 1923

Calvert Townley 1919-20 — Dugald C. Jackson 1910-11 — Paul M. Lincoln 1914-15 — Carl Hering 1900-1 — F. L. Hutchinson SECRETARY

E. W. Rice, Jr. 1917-18 — Charles F. Scott 1902-3 — William McClellan 1921-22 — John W. Lieb 1904-5

A. W. Berresford 1920-21 — Harris J. Ryan PRESIDENT ELECT — Charles P. Steinmetz 1901-2 — Frank B. Jewett 1922-23 — Comfort A. Adams 1918-1919

Ralph D. Mershon 1912-13 — T. Commerford Martin 1887-8 — Elihu Thomson 1889-90 — A. E. Kennelly 1898-1900

Telegraph Men Founders of the A.I.E.E.

By Donald McNicol, Fellow A.I.E.E.

Of the 25 men who signed the original organization call, 21 were in the telegraph business, as were also the Institute's first 2 presidents, 2 of the initial vice-presidents, and 4 of the initial managers.

PRIOR TO the formation of the American Institute of Electrical Engineers several electrical societies were operating locally in the large cities. The members of these local groups were engaged in the telegraph business, employed as teachers in colleges, and some were dabblers in electrical experiments.

The need for a national organization developed 6 or 8 months in advance of the opening of the International Electrical Exhibition held in Philadelphia, Pa., in 1884. In the April 15, 1884, issue of *The Operator* (the principal American electrical journal of that time) appeared a "call" for the formation of a national electrical society. One paragraph of the announcement read: "An International Electrical Exhibition is to be held in Philadelphia next autumn, to which many of the famous foreign electrical savants, engineers, and manufacturers will be visitors, and it would be a lasting disgrace to American electricians if no American electrical national society was in existence to receive them with the honors due them from their colaborers in the United States."

The American societies of civil, mechanical, and mining engineers had been in existence for some years, but apparently it required the spur of visitation from abroad to prompt the "electricians" to undertake the formation of a national society, with headquarters in New York.

In the call that was sent out another paragraph read: "It is proposed to make electrical engineers, electricians, instructors in schools and colleges, inventors and manufacturers of electrical apparatus, officers of telegraph, telephone, electric light, burglar alarm, district messenger, electric time and all companies based upon electrical inventions, as well as all who are disposed to support the organization for the common interest, eligible to membership."

The call was issued for a meeting to be held in the rooms of the American Society of Civil Engineers on May 13, 1884. Those who subscribed their names to the invitation were:

F. W. Jones, electrician, Bankers and Merchants Telegraph Co.
George B. Prescott, telegraph electrician.
George A. Hamilton, electrician, Western Union Telegraph Co.
Gerrit Smith, electrician, Western Union Telegraph Co.
E. A. Leslie, superintendent, Baltimore and Ohio Telegraph Co.
Norvin Green, president, Western Union Telegraph Co.
A. W. Dimock, president, Bankers and Merchants Telegraph Co.
W. J. Johnston, publisher, *The Operator*, a telegraph journal.
Stephen D. Field, electrician, Commercial Telegraph Co.
P. B. Delany, electrician, Multiplex Telegraph Co.
G. V. B. Frost, superintendent, American District Telegraph Co.
George B. Scott, superintendent, Gold and Stock Telegraph Co.
C. H. S. Small, assistant supt., Gold and Stock Telegraph Co.
C. L. Buckingham, counsel, Western Union Telegraph Co.
J. H. Bunnell, manufacturer of telegraph instruments.
W. C. Behrens, commissioner of underground wires.
E. A. Calahan, secretary, Standard Multiplex Telegraph Co.
Thomas A. Edison, inventor.
Theodore Mace, agent, Electrical Supply Co.
Thomas R. Taltavall, telegrapher.
L. G. Tillotson, manufacturer of telegraph apparatus.

In addition to these telegraph men there were 4 other signers, namely: P. H. Vander Weyde, president, New York Electrical Society; Rowland R. Hazard, President of the Grammer Electric Company; N. S. Keith, electrical engineer; C. O. Mailloux, electrical engineer.

Prior to the general meeting of May 13, a meeting of the signers of the call was held in the rooms of the A.S.C.E., on April 15, 1884. At this meeting also were present: Joseph P. Davis, vice-president of the Metropolitan Telegraph and Telephone Company; W. A. Hovey, president of the Merchants Electric Light Company, Boston; W. H. Eckert, general superintendent of the Metropolitan Telegraph and Telephone Company; George L. Beetle, Western Electric Company; and T. H. Delano, publisher of *The Electrical Review*.

At the meeting of May 13, a set of rules for the management of the Institute was adopted, which, in principle, are those that still exist. Norvin Green, president of the Western Union Telegraph Company, was elected the first president of the A.I.E.E. N. S. Keith was made secretary, and R. R. Hazard, treasurer. The vice-presidents elected were: A. G. Bell, Charles D. Cross, Thomas A. Edison, George A. Hamilton, Charles H. Haskins, and Frank L. Pope. The Managers elected were: Charles F. Brush, W. H. Eckert, S. D. Field, Elisha Gray, E. J. Houston, C. L. Hillings, F. W. Jones, George B. Prescott, W. W. Smith, W. P. Trowbridge, T. N. Vail, and Edward Weston. Others present at this meeting included Brig.-Gen. C. H. Barney, George S. Bowen, and Isaac Trumbo the latter from San Francisco, Calif.

A year after the Institute was organized Ralph W. Pope, who had been electrician of the Western Union Extension Telegraph, became secretary, continuing in this position until the time Mr. F. L. Hutchinson became secretary.

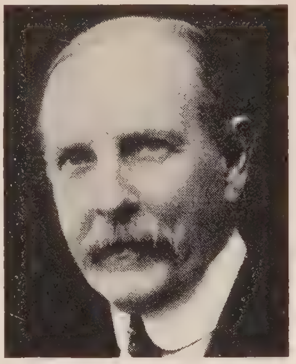
Following 1884, while the electric light, electric railway, telephone, and other electrical industries were growing to maturity, telegraph men continued to exercise influence in shaping the destiny of the Institute. So widely was this recognized that 20 years after the organization of the Institute, at the time Mr. Andrew Carnegie contributed upward of a million dollars toward the construction of the present headquarters building at 33 West 39th Street, New York, he said to Secretary Pope: "Well! the telegraph boys will now have a comfortable place to meet." Mr. Carnegie, himself, was an ex-telegrapher.

The Work of the Institute in Standardization

By A. E. Kennelly, President A.I.E.E. 1898–1900

An historical outline of the standardization activities of the A.I.E.E. is recorded in this article by a past-president who was chairman of the Institute's first standardization committee and who continuously since the appointment of that committee has been actively engaged not only in the standardization work of the Institute, but also in international standardization of electrical units.

THE American Institute of Electrical Engineers has had a remarkable history of standardization activities during the half century that has intervened since its founding in 1884. These activities may be divided into 3 categories: (1) work on units, standard definitions, and nomenclature relating to basic sciences underlying electrical engineering, beginning in 1890; (2) work on similar projects relating to applied science, engineering, and technology, beginning in 1898; and (3) work on projects relating to production and manufacture connected with electrical engineering, beginning in 1920. It is the purpose of this article to offer a brief outline of those activities.



First Recorded Action

The first action of the Institute in relation to standard units occurred on June 17, 1890 (v. 7, p. 89–90[1]) when Prof. F. G. Crocker offered a resolution "that the name of Henry should be given to the practical unit of self-induction." This resolution was adopted and a committee was appointed to report upon the recommended magnitude of the unit. The committee reported January 20, 1891 (v. 8, p. 31) in favor of the magnitude in the practical electromagnetic unit series, *i. e.*, 10^9 c.g.s. magnetic units of inductance, a magnitude already known as the "quadrant," or the "secohm." It is thus interesting to notice that the first standardization recommendation of the Institute was in favor of the name "henry" for the practical unit of inductance.

The Units and Standards (U.&S.) Committee

About the same date (June 1891) the Institute appointed its first standing committee on standardization—the committee on "units and standards." The members of this committee were: A. E. Kennelly, *chairman*, F. B. Crocker, W. E. Geyer, G. A. Hamilton, and G. B. Prescott, Jr.

The U.&S. committee made its first report on June 20, 1891, suggesting that the Institute should recommend to the next International Electrical Congress (Chicago 1893) 4 practical electromagnetic units as follows:

1. A practical unit of magnetomotive force equal to $^1/_{4\pi}$th ampere turn.
2. A practical unit of magnetic flux equal to 10^9 c.g.s. magnetic units
3. A practical unit of flux density equal to 10^9 c.g.s. magnetic units per square centimeter.
4. A practical unit of reluctance, in conformity with units 1 and 2.

It was suggested also that appropriate names should be assigned to these units; but no names were offered. The report was forthwith accepted by the Institute (v. 8, p. 536).

The Institute had also appointed a "standard wiring table committee," to assign the linear resistance of standard-conductivity copper wire of British and American gauges (B.W.G. and A.W.G. or B.&S.) and at standard temperatures (20, 50, and 80 deg C). The personnel was F. B. Crocker, *chairman*, G. Duncan, W. B. Geyer, A. E. Kennelly, G. B. Prescott, E. W. Rice, Jr., M. P. Roberts, H. J. Ryan, W. Stanley, Jr., and S. S. Wheeler. The committee presented a report in 1893 (v. 10, p. 21–5), and prepared a wire table (v. 10, opposite p. 668) part of which is reproduced on the next page.

International Electrical Congress, 1893

A committee also was appointed to prepare a provisional program for the chamber of delegates of the forthcoming International Electrical Congress of Chicago (1893) in regard to units, standards, and nomenclature. Its personnel was: Carl Hering *chairman*, W. A. Anthony, and A. E. Kennelly. The committee reported in January 1893, including the U.&S. committee report of June 1891 referred to previously (v. 10, p. 1–16).

The Chicago congress voted against adopting magnetic units in the practical series, and recommended the retention of the magnetic units in the c.g.s. system, for the present without names. However, the congress adopted the name "henry" for the practical unit of inductance, at the value of 10^9 c.g.s. magnetic units. It also drew up specifications for the practical unit standards under the name of "international electrical units."

In view of the actions of the Chicago congress with respect to magnetic units, the U.&S. committee of the Institute brought in a report November 15 1893 (v. 11, p. 48–9), recommending the Institute's provisional adoption of the following 4 names for c.g.s. magnetic units; "gilbert" for magnetomotive force, "weber" for flux, "oersted" for reluctance, and "gauss" for flux density. At the first reading, the report was laid on the table; but at a subsequent meeting, on March 21, 1894, the report was re-

1. All bibliographic references refer to A.I.E.E. Transactions.

considered (v. 11, p. 124) and, after discussion, was provisionally adopted (p. 132).

The U. & S. committee also recommended to the Institute that the United States Congress be urged to pass a bill for legislative action on the international series of electrical units adopted by the Chicago electrical congress (May 1894, v. 11, p. 189–90). This resolution was adopted.

In 1894, differences of opinion presented themselves among the members of the Institute as to the meaning of the term "inductance." With a view to securing international agreement on the definition of this term, the U. & S. committee consulted the Institution of Electrical Engineers in London, the Société Française des Electriciens in Paris, and the Elektrotechnischer Verein also the Physikalisch-Technische Reichsanstalt in Berlin. On the basis of the replies received, the U. & S. committee recommended that the Institute should adopt the term "inductance" as meaning a coefficient of induction, with symbol *L*. The report was adopted May 1894 (v. 11, p. 253–60). The corresponding present definition of the term "reactance" then proposed by Doctor Steinmetz, also was adopted forthwith.

In December 1894, the U. & S. committee reported to the Institute (v. 11, p. 827–9), citing the act of Congress H.R. 6,500, legalizing, in the United States, the international electrical units adopted by the Chicago congress.

Standards of Luminous Intensity

On January 19, 1897 (v. 14, p. 90) the U.&S. committee recommended to the Institute that the amylacetate Hefner-Alteneck lamp should be adopted temporarily as standard of luminous intensity or candlepower, under standard specifications. The committee recommended also that the Lummer-Brodhun photometer screen be adopted for measuring the mean horizontal intensity of incandescent lamps, the lamp being rotated about its vertical axis at a speed of about 2 turns per second. It was recommended further that the mean spherical candlepower of a lamp should be used as far as practicable.

[Supplement to Transactions October 1893.]

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.

COPPER WIRE TABLE.

Giving weights, lengths, and resistances of cool, warm, and hot wires, of Matthiessen's standard conductivity, for both A. W. G. (Brown & Sharpe) and B. W. G.

GAUGES To the nearest fourth significant digit.				WEIGHT.				LENGTH.				RESISTANCE.					
A.W.G.	B.W.G.	Diameter.	Area.	Lbs. per foot.	Lbs. per Ohm.			Feet per lb.	Feet per Ohm.			Ohms per lb.			Ohms per foot.		
B. & S.	Stub's	Inches.	Circular mils.		@ 20° C.	@ 50° C.	@ 80° C.		@ 20° C.	@ 50° C.	@ 80° C.	@ 20° C.	@ 50° C.	@ 80° C.	@ 20° C.	@ 50° C.	@ 80° C.
0000		0.460	211,600	0.6405	13,090	11,720	10,570	1.561	20,440	18,290	16,510	0.00007639	0.00008535	0.00009459	0.00004893	0.00005467	0.00006058
	0000	0.454	206,100	0.6239	12,420	11,120	10,030	1.603	19,910	17,820	16,080	0.00008051	0.00008996	0.00009969	0.00005023	0.00005612	0.00006220
	000	0.425	180,600	0.5468	9,538	8,537	7,704	[illegible]	[illegible]	15,620	14,090	0.0001048	0.0001171	0.0001298	0.00005732	0.00006404	0.00007097
			[illegible]	0.00004843	0.00007404	[illegible]	0.00006045	20,650	1.545	[illegible]							
[illegible]		0.003965	15.72	0.00004759	0.00007210	0.00006454	0.00005824	21,010	1.519	1.359	[illegible]					[illegible]	[illegible]
39		0.003531	12.47	0.00003774	0.00004545	0.00004068	0.00003671	26,500	1.204	1.078	0.9726	22,000	24,580	27,240	0.8304	0.9277	1.028
40		0.003145	9.888	0.00002993	0.00002858	0.00002559	0.00002309	33,410	0.9550	0.8548	0.7713	34,980	39,080	43,320	1.047	1.170	1.296

The data from which this table has been computed are as follows:—Matthiessen's standard resistivity, Matthiessen's temperature coefficients, specific gravity of copper = 8.89. Resistance in terms of the international ohm.
Matthiessen's standard 1 metre-gramme of hard drawn copper = 0.1469 B. A. U. @ 0° C. Ratio of resistivity hard to soft copper 1.0226.
1 " soft " = 0.14365 B. A. U. @ 0° C. One B. A. U. = 0.9866 international ohms.
1 " soft " = 0.141729 international ohm @ 0° C.
Temperature coefficients of resistance for 20° C., 50° C., and 80° C., 1.07968, 1.20625, and 1.33681 respectively. 1 foot = 0.3048028 metre, 1 pound = 453.59256 grammes.
Although the entries in the table are carried to the fourth significant digit, the computations have been carried to at least five figures. The last digit is therefore correct to within half a unit, representing an arithmetical degree of accuracy of at least one part in two thousand. The diameters of the B. & S. or A. W. G. wires are obtained from the geometrical series in which No. 0000 = 0.4600 inch and No. 36 = 0.005 inch, the nearest fourth significant digit being retained in the areas and diameters so deduced.
It is to be observed that while Matthiessen's standard of resistivity may be permanently recognized, the temperature coefficient of its variation which he introduced, and which is here used may in future undergo slight revision.

F. B. CROCKER, W. E. GEYER, G. A. HAMILTON, A. E. KENNELLY, Chairman, Committee on "Units and Standards."

Standard copper wire table of linear resistivity prepared by an Institute committee in 1893 and published in the TRANSACTIONS (v. 10, opposite p. 668) (Top and bottom portions only are shown)

Concurrent A.I.E.E. meetings were held in New York and Chicago (January 26, 1898, v. 15, p. 2–32) devoted to the topical discussion of "The Standardization of Generators, Motors, and Transformers," led by F. B. Crocker in New York, and B. J. Arnold in Chicago. As a result of these discussions, the A.I.E.E. council shortly afterward appointed a "committee on standardization" with the following membership: F. B. Crocker, *chairman*, C. T. Hutchinson, A. E. Kennelly, J. W. Lieb, C. P. Steinmetz, L. B. Stillwell, and E. Thomson. The influence of this committee in electrotechnics and engineering has been so important down to the present day that a brief account of its aims should be given here. The policy of the committee originally planned has remained fairly uniform throughout, as an inspection of its various successive reports will show.

The committee sought to avoid all standardization of sizes or dimensions of electrical machinery. It aimed to define and state in as simple language as practicable, the nature, characteristics, behavior, rating, and methods of testing of electrical machinery and apparatus, particularly with a view to setting up acceptance test standards for electrical industry.

The first report of the standardization committee was adopted by the Institute June 26, 1899 (v. 16, p. 255–68); it also was printed in the A.I.E.E. handbook for 1900, p. 124–36. It included the following subject headings: Efficiency, Rise of Temperature, Insulation, Regulation, Variation and Pulsation, Classification of Voltages, Overloads, etc. There was a considerable demand for the report in the industry from the date of its first appearance, and some 900 copies had been distributed by May 17, 1900 (v. 17). A second report of the standardization committee, revised and enlarged was presented at the A.I.E.E. convention in Great Barrington, Mass., June 20, 1902 (v. 19, 1902, p. 1076–91). After 1902, the successive reports of the committee were reprinted under the title "Standardization Rules of the A.I.E.E." When the A.I.E.E. constitution was amended in May 1907, the standardization committee was established as a standing committee of the Institute, and its name was changed to the "standards committee," which it remains to the present day.

International Electrical Congress at Paris, 1900

The units and standards committee recommended to the Institute May 17, 1900 (v. 17, 1901, p. 309–18) that at the forthcoming Paris congress, names should be advocated for 4 c.g.s. magnetic units provisionally adopted by the Institute in November 1893; also the principle of prefixes for them. The committee also recommended that the question of rationalizing them should be discussed. The committee report was adopted for presentation to the congress.

At the Paris congress, the chamber of delegates limited consideration to 2 c.g.s. unit names only the "maxwell" and the "gauss." The name "maxwell" was assigned to the c.g.s. unit of magnetic flux, Φ, in accordance with A.I.E.E. recommendation; but there was some misunderstanding as to the unit receiving the name "gauss." The A.I.E.E. delegates believed that it had been adopted for flux density, B, as adopted provisionally by the Institute in 1893, and as advocated by them at Paris. They reported to the Institute in November 1900, that the name "gauss" had been adopted for flux density, B (v. 17, p. 543–7); but the official minutes of the congress, published in 1901, showed that the name "gauss" had been assigned to magnetic field intensity, H. In the English text of the congress preliminary report printed in the A.I.E.E. Transactions (v. 17, p. 552) "gauss" for field density was also ambiguous. This accidental misunderstanding led subsequently to considerable confusion in magnetic literature.

Establishment of the U.S. Bureau of Standards

The Institute endorsed in 1901 (v. 17, p. 615) bills then before the U.S. Congress for establishing a national standardizing bureau at Washington, D. C., "for the construction, custody, and comparison of standards used in scientific and technical work." This bureau, created shortly afterward, came to be known as the National Bureau of Standards, and has exerted a marked influence on science, engineering, and industry. Close connection has been maintained between the Institute's committees and the Bureau of Standards.

International Electrical Congress of St. Louis, 1904

The St. Louis congress was notable in the history of the Institute's work of standardization as being the last electrical congress held in America, and as having taken actions in its chamber of delegates that completely changed the procedure of international electrical congresses since 1904, in reference to electrical units and standards.

The congress met September 12–17, 1904, close to the Exposition buildings. The work was distributed under 8 sections, 2 for theory and 6 for applications. There were 3 volumes of transactions, containing 158 papers. The organization was prepared by the Institute. The president was Prof. E. Thomson; honorary vice-presidents: Ascoli, Crompton, Glazebrook, Gonzales, Gray, Lombardi, Perry, and Poincaré; vice-presidents: Arnold, Carhart, Goldsborough, Scott, and Stratton; general secretary, Kennelly; and treasurer, Weaver.

The chamber of delegates, in which 11 countries were represented, decided that it would not be desirable to undertake international standardization by the St. Louis congress. It unanimously recommended, however, that 2 international commissions should be established: (1) to consist of government representatives charged with the legal maintenance of electrical standards in the various

ountries, to deal with such units and standards; nd (2) to consist of representatives of various ational electrotechnical societies, to deal with the tandardization of electrical apparatus and mahinery. These recommendations were adopted.

Commission 1 later came into operation as Interational Conferences on Electrical Units in 1905 t Berlin, and again at London in 1908. The last amed was attended by government delegates from 4 countries. Important standardization work was ccomplished at these conferences in reference to the naintenance of precise standards of legalized elecrical units. In pursuance of this work, an interational technical committee from the national aboratories of France, Germany, Great Britain, nd the United States, met at Washington in 1910.

In October 1933, the Eighth International Conerence of Weights and Measures at Sèvres, adopted resolution assuming the continuation of the London onference of 1908. In that sense, therefore, comnission 1 organized at the St. Louis congress of 904, may be regarded as maintaining a continued xistence.

NTERNATIONAL ELECTROTECHNICAL COMMISSION

Commission 2 organized at the St. Louis congress ater came into operation as the International Elecrotechnical Commission (I.E.C.). It was organized n 1905, under the auspices of Col. R. E. Crompton, vho was an honorary vice-president of the St. Louis ongress. Mr. C. Lemaistre was appointed its genral secretary, with offices at 28 Victoria St., London. The first meeting of the I.E.C. was held at London, or organization, in 1906, when Lord Kelvin was lected the first president.

The I.E.C. is maintained by some 25 countries, ach of which has a standing national committee vith local officers. The work is divided among 18 echnical advisory committees, holding meetings from ime to time and reporting their decisions at succesive general conventions. There have been 19 of hese general conventions to date, in the cities of London (1906, '08, '19, and '24), Brussels (1910 nd '20), Cologne (1911 and '13), Turin (1911), Paris (1912, '19, and '23), Zurich (1913), Berlin 1913), Geneva (1922), The Hague (1925), New York (1926), Bellagio (1927), and Copenhagen-Stockholm-Oslo in 1930.

The Institute has taken an active share in the naintenance of the U.S. national committee, and fter 1908 kept a standing I.E.C. committee the hairmen of which have been F. B. Crocker, E. Thomson, C. O. Mailloux, A. E. Kennelly, D. C. Jackson, and C. H. Sharp. The international presidents have been Kelvin, Thomson, Budde, Leblanc, Mailloux, Semenza, Feldmann, and Enström. There have been 3 honorary presidents: Mailloux, Crompton, and Semenza. Among the dvisory committees are those on the rating of lectrical machinery, glossary of terms, units, symols, voltages, etc.

The U.S. national committee of the I.E.C. inludes representatives of the Institute, the American Society of Mechanical Engineers, the American Society for Testing Materials, the Electrical Manufacturers Association, several departments of the U.S. government, and the American Standards Association, the secretary of which, Dr. P. G. Agnew, is also secretary of the U.S. national committee of the I.E.C.

The standardization work of the I.E.C. and of its constituent national committees is basically in electrical engineering; however, owing to the close association of steam engines and hydraulics with electric generation, some I.E.C. technical committees deal with fields of mechanical and civil engineering, such as turbines and ratings of rivets.

Since the Bellagio meeting of 1927, the I.E.C. has taken steps to standardize the names and definitions of the c.g.s. magnetic units. Section *B* of advisory committee No. 1 for nomenclature on "electric and magnetic magnitudes and units" (E.M.M.U.) has held meetings at Stockholm (1930), London (1931), and Paris (1933) at which certain conventions have been recommended for eliminating ambiguity and confusion in international magnetic literature (I.E.C. Documents R.M. 77, 97, and 105). In this undertaking, the aid of the International Union of Pure and Applied Physics has been invoked, through that union's committee on symbols, units, and nomenclature (S.U.N.) which held a meeting at Paris in July 1932, devoted to the same topics.

At the Turin meeting of the I.E.C. in 1911, unanimous agreement was reached on the standard direction of phase advance in vector diagrams, and on the standard direction of inductive reactance in impedance vector triangles ($R + jX$) (v. 30, 1911, p. 2371).

Since 1911, the I.E.C. has been recognized as granting authorization for holding international electrical congresses. No such congresses have undertaken to establish new electrical units.

INTERNATIONAL COMMISSION ON ILLUMINATION (COMMISSION INTERNATIONALE DE L'ECLAIRAGE)

This international body was the successor of the Commission Internationale de Photometrie, and has national committees in 15 countries. Its first meeting was at Berlin in 1913. Its central office is at the National Physical Laboratory, Teddington, England. Since 1913, the A.I.E.E. has appointed 3 representatives each year to the U.S. national committee of the I.C.I. The last meeting of the Commission was held at Cambridge, England, in 1931.

The I.C.I. undertakes to establish units, standards, and nomenclature in the science and technology of light and illumination. The president of the U.S. national committee is E. C. Crittenden, at the U.S. Bureau of Standards, and the secretary is G. H. Stickney, at Nela Park, Cleveland, Ohio.

AMERICAN STANDARDS ASSOCIATION (A.S.A.)

This organization, formerly the American Engineering Standards Committee (A.E.S.C.), has been aptly described as a "national clearing house for industrial standardization." It is composed of a

number of engineering societies, manufacturing associations, and operating or consumers associations. Its main purposes are to simplify and standardize production and construction, with the elimination of overlapping, reduplication, and waste. By establishing standards in sizes, specifications, and tests, it enables marked economies to be effected in manufacture and service. The A.E.S.C. was organized in 1919. In recent years, its name has been changed to the American Standards Association (A.S.A). Since 1920, the Institute annually has appointed representatives on the council of the A.S.A. The headquarters of the A.S.A. are in the Engineering Building, New York, N. Y., and its secretary is Dr. P. G. Agnew.

Scientific and Engineering Symbols and Abbreviations

The Institute took part in standardizing engineering symbols and abbreviations in 1926, under the auspices of the American Standards Association. Other sponsoring bodies were the American Association for the Advancement of Science, the American Society of Civil Engineers, The American Society of Mechanical Engineers, and the Society for the Promotion of Engineering Education. The chairman of the section committee was Dr. J. F. Meyer, and the secretary was Mr. P. S. Millar. Nine subcommittees were formed to cover different departments of the work. The subcommittee on mathematical symbols (project Z10f) had 14 members and Prof. E. V. Huntington was the chairman. This work was approved by the A.S.A. in January 1928. For purposes of amplification and revision the original committee is being continued but with some subdivision and reorganization of both scope and personnel.

Standard Definitions of Electrical Terms

The Institute was made sponsor for a glossary of electrical engineering terms, under the auspices of the A.S.A. in 1928. Some 30 scientific and engineering societies and organizations are represented on the sectional committee, the chairman of which is Prof. A. E. Kennelly, and the secretary, Mr. H. E. Farrer. The committee is divided into 18 subcommittees with the following chairmen: Messrs. H. L. Curtis, C. V. Christie, R. C. Sogge, H. E. Ruggles, H. D. James, J. F. Meyer, C. H. Sanderson, J. H. Davis, E. B. Paxton, F. M. Farmer, C. H. Sharp, G. W. Vinal, W. H. Martin, H. Pratt, M. G. Lloyd, and W. Wilson.

The personnel includes a total of about 120 members; including the experts consulted in the work, a personnel of more than 300 members are engaged. The numerical classification adopted was by group, section, and term numbers, designed to correspond with those proposed by the nomenclature of the International Electrotechnical Commission.

The sectional committee brought in a report which was printed by the Institute in August 1932. This report included more than 3,000 terms. The published report is in process of amendment and amplification prior to being submitted for acceptance by the coöperating organizations and the American Standards Association.

Summary

It has been pointed out that almost from its foundation 50 years ago, the Institute has actively engaged in standardization. It has done this through appointing many of its members to service on committees of standardization, and by expending a very appreciable share of its revenue on the publication of the results. It also has fostered many papers and discussions.

The Institute's standardization work may be divided into 3 categories:

1. Work on units, standards definitions, and nomenclature relating to basic sciences underlying electrical engineering.

2. Work on similar projects relating to applied science, engineering, and technology.

3. Work on projects relating to production and manufacture connected with electrical engineering.

These 3 classes of standardization may briefly be called: (1) basic, (2) technical, and (3) manufacturing standardization. Each is so important to the welfare of engineering, that the question of their relative importance to the Institute becomes insignificant.

1. The Institute's basic standardization, relating mainly to the sciences of physics, chemistry, and mathematics, has been carried on in large measure through the International Electrotechnical Commission (I.E.C.) and the International Commission on Illumination (I.C.I.), such work being mostly of an international character. It also has carried on such work through international electrical congresses, and through special committees of its own and allied societies dealing with basic subjects.

2. The Institute's technical standardization, relating to engineering practice, has been carried on largely through its standards committee, which was appointed in 1898 and is still actively at work. It has dealt principally with standard definitions, behavior, and tests of energy transporting and transforming machinery and apparatus, as used in the various branches of electrical engineering.

3. The Institute's share in manufacturing standardization, relating mainly to economical production, has been conducted principally through the Electrical Standards Committee, an organization representing the entire electrical industry, and the American Standards Association (A.S.A.), an organization representing all industries connected with engineering.

It is interesting to observe that the Institute's basic standardization was first in order of development, going back to 1890. Its technical standardization came next, the standards committee having been appointed in 1898. The participation in manufacturing standardization did not take effect until about 1920. There is every reason to expect that the Institute's future will be as closely associated with standardization along all 3 lines, as has been its past.

The Institute and Industrial Standardization

By C. E. Skinner, President A.I.E.E. 1931–32

The Institute's standardizing committee, which has been in existence for 36 of the Institute's 50 years, was the first official group representing designers, manufacturers, and operators of electrical apparatus in a joint effort to arrive at mutual understandings. These cooperative efforts have been continued until today the Institute holds a major place in the formulation and approval of electrical standards in the United States and has an important rôle to play in international electrical standardization.

DURING the 36 years since its conception, the standards com-nittee of the American In-stitute of Electrical Engi-eers has rendered a most signal service to American electrical industry and to the world. Brought into being in a spirit of coöpera-ion, then unusual in indus-ry, it has continued as an agency in bringing all parties at interest together n sincere efforts to arrive at mutually satisfactory understandings. Its goal has ever been to reach the ideal and it has uncompromisingly followed this deal when fundamental principles were at stake. It has always sought to com-bine the ideal with the practical in its consideration of those problems which have a commercial bearing and which do not permit an exact solution.

A roster of its members through the years includes many names of men known throughout the world for their contributions to almost every phase of the electrical art. A large percentage of the men who have attained the presidency of the Institute have served as earnest working members. Its rules, promulgated from time to time and changed as became necessary with the developing industry, have exerted a profound influence in shaping and guiding the industry, and this influence has extended into all industrial countries. Its example and accomplishments have influenced standardization in many other fields.

On January 26, 1898, at a New York meeting of the Institute, Dr. Francis B. Crocker, then president, introduced a general discussion on "The Standardizing of Generators, Motors, and Transformers." A very spirited discussion ensued, the general idea of establishing standards being highly commended by all who took part. Those participating in this discussion were: E. W. Rice, Jr., W. A. Mosscrop, Robert T. E. Lozier, A. E. Kennelly, Townsend Wolcott, Cary T. Hutchinson, John W. Lieb, Jr., Gano S. Dunn, H. B. Coho, Frank A. Pattison, F. V. Henshaw, N. M. Hopkins, Charles P. Steinmetz, C. O. Mailloux, and Max Osterberg. Simultaneously a discussion was held in Chicago on the same subject; those participating were: B. J. Arnold, a Mr. Meyer, . R. Cravath, a Mr. Hickok, George A. Damon, and Prof. W. M. Stine. In addition to the discussions at these 2 meetings, a written discussion was communicated to A.I.E.E. headquarters (and published) by Prof. Charles F. Scott.

As a result of this discussion, the board of directors voted to organize a standardizing committee, and the members of the first committee were appointed on March 23, 1898. There is no more outstanding group of men in the Institute membership than that group. With one exception, each has served the Institute as its president, and all have received world-wide recognition in the electrical field. This first committee consisted of the following:

Francis B. Crocker, *chairman*
Cary T. Hutchinson
Arthur E. Kennelly
Charles P. Steinmetz
Elihu Thompson
John W. Lieb
Lewis B. Stillwell

This first committee wisely confined itself to establishing standards of performance for electrical machinery and apparatus, leaving the manufacturer and the user free to secure that performance by any design and construction found desirable. Definitions and nomenclature were a necessary part of its first report. Fundamental units so far as established were accepted as the basis of measurements. This general policy has been adhered to through the years regardless of the many changes in the personnel of the committee.

Bitter Rivalry in Early Electrical Industry

It should be remembered that at the time of organization of the committee, there was intense and even bitter rivalry in the electrical industry. The battle of the systems was still in progress. Different groups advocated different frequencies for the alternating current field. Transmission voltages were undergoing a constant revision and change. No temperature limits were set, and the method of measuring temperature was not fixed. The method of designating rating varied with the product. No established standard for dielectric tests was in force. Methods of measuring efficiency were in a very nebulous state. There was much confusion in connection with methods of measurement and test. Many honest differences of opinion were being debated with great vigor in the various meetings of the Institute. Commercial rivalry resulted in a multitude of terms and specifications used and issued by

individual groups. Frequently users of electrical equipment had no means of comparing tenders from different manufacturers as these often were couched in terms of the manufacturer's own choosing.

This standardizing committee was, therefore, the first official group representing designers, manufacturers, users, and operators to sit around the table and try to arrive at mutual understandings which would provide a common language, and place all engineers, manufacturers, purchasers, and operators on a common and understandable footing.

The Institute's First Report on Standardization

The first report of the original committee was accepted by the Institute at its meeting in June 1899. This report is a remarkable document, bringing together as it did, authoritative statements agreed to by this eminent body of men and their advisers on the major items which since have become the groundwork of all our electrical standardization. This first report dealt with the following subjects:

1. Efficiency.
   (a) Commutating machines.
   (b) Synchronous machines.
   (c) Synchronous commutating machines.
   (d) Rectifying machines.
   (e) Stationary induction apparatus.
   (f) Rotary induction apparatus.
   (g) Transmission lines.
2. Rise of temperatures.
3. Insulation.
4. Regulation.
5. Variation and pulsation.
6. Rating.
7. Classification of voltages and frequencies.
8. Overload capacities.
9. Appendices.
   (a) Efficiency.
   (b) Apparent efficiencies.
   (c) Power factor and inductance factor.
   (d) Notation.
   (e) Table of sparking distances.

This report was not made mandatory in the electrical industry but was recommended for trial. Manufacturers and users alike welcomed this attempt to end the chaotic conditions that previously had existed. Experience gained in application of the standards and further developments in apparatus and methods, showed the necessity of revision. A committee was appointed which, after consultation with manufacturing and operating engineers, presented the first revised report on standardization rules of the A.I.E.E. in June 1902.

The rapidly growing and changing electrical art made revision of the rules necessary from time to time. A second revision was presented in May 1906 and a third in June 1907. By this time, the very great importance and value of standardization became recognized throughout the whole industry and a standing committee with the title of "standards committee of the A.I.E.E." became effective in the constitution June 1907. The scope and work of the committee necessitated increasing the number of members from time to time until in 1922 there were 37 members divided into a number of subcommittees specializing on various subjects. Up until this time the standards rules, as developed by the standards committee and adopted by the board of directors, were published in a single volume. Nine such volumes have been issued, each with certain revisions and additions as were necessitated by experience and by the changing electrical art.

Because of the increased complexity of the standardization work and its extension into many fields, each requiring revision from time to time, it was decided in June 1922 to change the general plan of operation and to organize working committees, including non-Institute members, to deal with specific subjects. These working committees reported their findings to the main standards committee, which had final jurisdiction over the reports. It was further decided that the standards for each subject should be published separately, in each case the standard so published to be complete in itself. This division of the standards into specific subjects has simplified very greatly the process of keeping them revised and up to date. The work has continued until at present there are more than 40 sections of the standards each in separate pamphlet form. Very recently the plan of grouping those of the same general class has been proposed. As revisions now are less frequent, this would make for economy and convenience.

A.I.E.E. Standards Widely Accepted

Because of their intrinsic worth, the A.I.E.E. rules from the first have been generally accepted by all branches of the American electrical industry as the standards governing the performance, method of test, and application of electrical apparatus and equipment. These results were not achieved, however, without a very great amount of discussion, trial, test, and compromise. The difficult subject of rating was discussed, debated, and even fought over for years. It is difficult to determine the exact limitations of the capability of a machine in any given service, and as similar machines often are required to perform in a multitude of different services, the subject of rating becomes very complicated. Many tests were made and many different opinions were debated in the attempt to arrive at a practical solution and agreement on this difficult question. Again, the temperatures that insulating material of various classes will withstand without serious deterioration is almost impossible to evaluate with any exactness. The final figures adopted are the results of many tests in the laboratory and long experience in the field.

The methods of measuring the actual temperature of an electrical machine present many difficulties. Thousands of man-hours have been spent in tests, measurements, and debates on this subject. Even the apparently simple measurement of temperature by thermometer proved a very difficult subject, and rigid rules were required to enable different observers to obtain reasonably consistent results. Measurement of temperature by change of resistance of windings also presents difficulties; and as the re-

ults give the average temperature only, the actual hottest spots never are found by this method.

These difficulties led the standards committee to eek an accurate method of locating and measuring he maximum temperature reached at any point in he windings, particularly of large and important nachines and apparatus. This resulted in the development of internal temperature detectors by mbedded resistance coils and thermocouples. Again, much experimental work and many debates were required before exact rules and limitations ould be agreed to by the various parties at interest. Overload capacities for various services and the nethod of measuring such capacities is another phase of standards work that required much attenion.

Dielectric tests and methods of making them have taken much time and attention, and have required many changes with experience and the hanging designs and requirements from year to year. The measurement of test voltages has been he subject of much experimental work by the best equipped laboratories of both America and Europe. The measurement of efficiency has been one of the nost difficult phases of the work, and it is only within recent months that the formulation of a test ode on this subject has reached a point where it ould be submitted for general approval.

International Standardization

The International Electrotechnical Commission, which is the international standardizing agency in he electrical field, was organized largely through he suggestion of Colonel Crompton of England, ollowing a conference of various "nationals" at the St. Louis Exposition in 1904. For a number of years, the A.I.E.E., and particularly its standards ommittee, operated as the United States representaive of the I.E.C. From time to time delegates were sent by the A.I.E.E. to meetings of the I.E.C. n Europe, with the object of bringing about international electrical standardization. If the work of the standards committee of the A.I.E.E. was beset with many difficulties, to these were added many others when international standardization was atempted. These added international difficulties are lue to such things as fundamental developments along different lines in different countries; differences in language, difference in methods of adminisration, and many others. However, considerable progress has been made through the work of this ommission so that there is now at least a common anguage available for the discussion of electrical natters in the various industrial countries. Special redit should be given to the late Dr. C. O. Mailloux and to Dr. A. E. Kennelly, Institute representatives at many international meetings, who were especially active and effective in the organization and in the haping of the policies of the I.E.C.

Due to the requirements of the constitution of the I.E.C. and the recognized desirability of bringing all American parties of interest into the international work, the United States Committee of the I.E.C. was enlarged to include the National Electric Light Association and the National Electrical Manufacturers Association; later the work was broadened still further and representatives of the American Society of Mechanical Engineers and the American Society for Testing Materials were added to the United States committee membership. With increased personnel, increased funds, and increased enthusiasm, the work of the I.E.C. has gone forward so that there is now agreement in many important matters in all industrial countries in the electrical standardization field.

American Standards Association

Delegates to European conferences of the I.E.C. in the early days frequently were called upon to state which were the authoritative American standards. This question arose from the fact that other groups, such as the National Electrical Manufacturers Association, had adopted certain standards, sometimes overlapping but usually covering a somewhat different field from those promulgated by the A.I.E.E. These questions emphasized the desirability of establishing an authoritative organization composed of the standard making bodies of the United States which would be empowered to pass upon and to certify those standards which had the adherence of all interested organizations and which, therefore, could be considered as truly American standards. The A.I.E.E. through its standards committee was very glad, therefore, to coöperate with the suggestion that such an authoritative body be formed. This brought into being the American Engineering Standards Committee, later designated as the American Standards Association. The A.E.S.C. was organized by appointed representatives of the 4 national societies of civil, mining, mechanical, and electrical engineers, and the American Society for Testing Materials. The original plan of operation, which has been adhered to consistently, provided that the A.S.A. should be a standards approving body and not a standards making body. Its rules provide for an orderly method of ascertaining whether or not a proposed standard is acceptable to all major parties at interest, and if so, giving it the stamp of approval as an American standard. From time to time additional groups have joined the A.S.A. so that it now consists of 37 member body groups made up of technical and trade associations and Federal Government departments.

The following 2 paragraphs regarding the organization and direction of A.S.A. and its relations with coöperating bodies are found in the American Standards Year Book, 1932–33, p. 8:

"The general direction of A.S.A. affairs is in the hands of a Board of Directors made up of nationally known industrial executives, while the final approval of standards that have been duly submitted by technical committees rests with the Standards Council, composed of representatives of all Member-Bodies of the Association. The details of the Association's work are handled by a staff of trained workers, including engineers who have had practical industrial experience."

"Any organization officially coöperating in A.S.A. work is called a coöperating body as soon as it appoints a representative on a technical committee, or on a committee doing equivalent work. About 475 national organizations are officially coöperating in A.S.A. activi-

ties in this way through 2,700 technical experts appointed as their representatives."

Electrical Standards Committee

After much debate and the consideration of many plans looking to a satisfactory method of coöperation with and adherence to the A.S.A., the A.I.E.E. participated with other electrical groups in the organization of an Electrical Standards Committee (E.S.C.) representative of all American electrical industry. The functions of the E.S.C. as outlined recently by its chairman, Charles Rufus Harte, are as follows:

1. Advisory committee to the standards council (of A.S.A.) for the coördination of standardization work in the electrical field under any recognized procedure of the American Standards Association, with the right to determine questions of sponsorship, scope of projects, and the personnel of sectional committees.

2. Sponsor for projects on behalf of the electrical industry.

3. Sectional committee for the electrical industry, under E.S.C. sponsorship (as provided above). In such cases the formulation of standards may be done by the E.S.C. itself, or by delegation to appropriate working committees at the discretion of the E.S.C.

4. The coördinating medium for American participation in international standardization work within the electrical field.

5. Representative of the electrical industry in the case of projects which involve other industrial as well as the electrical industry, to the extent of determining or recommending a sponsor to act for the qualified and interested groups, or, where the interests of the electrical industry do not warrant sponsorship, to recommend the degree of coöperation desirable in the particular project. The vote of the E.S.C. required on such actions is determined by their relation to actions under the previous classifications.

The E.S.C. is therefore the connecting link between A.S.A. and all groups interested in electrical standardization. The A.I.E.E. still maintains its standards committee which develops or passes upon all new standards of specific interest to the Institute group and is the medium for the revision of standards previously adopted by the Institute. New standards originating either within Institute groups or referred to the Institute through E.S.C. are dealt with by the standards committee. When sponsorship is assigned to the Institute, the standards committee becomes the executive group to carry out the coöperative work required in the formulation of the new standard. Standards formulated within the Institute for which "American Standard" status is desired, are submitted to the E.S.C., which in turn makes its recommendation to the A.S.A. in regard to their status as American standards or tentative standards.

The present arrangement for the initiation, the formulation, and approval of electrical standards has been arrived at only after much debate, consideration of the method of other organizations and evolution from the original self-contained A. I. E. E. standards committee. The present scheme of an electrical standards committee representative of all major interest tying in with the work of specific groups, such as A.I.E.E. standards committee on the one hand, and acting as advisory to A.S.A. seems to be the most flexible and satisfactory arrangements yet evolved in the making of American standards. The Institute holds a major place in the formulation and approval of electrical standards in the United States and has an important rôle to play in future international electrical standardization. It has reason to be proud of its standardization work of the past, and the present cordial coöperative arrangements assure a harmonious and satisfactory part in the electrical standardization of the future.

A Group of Prominent Institute Members in 1897

A picture taken at Schenectady N.Y., September 24, 1897, during th last visit of Lord Kelvin to the Unite States. Those in the picture, wi year of election to the Institute, ar Albert L. Rohrer (A'87, M'8 member for life); George E. Emmon Charles P. Steinmetz (A'90, M'9 F'12); Prof. Elihu Thomson (A'8 M'91, F'13, member for life); Lad Kelvin; Lord Kelvin (HM'92 Spencer Trask; Ogden Mills; ar George Foster Peabody. Betwe Professor Thomson and Lady Kelv is Edwin W. Rice, Jr. (A'87, M'8 F'13, member for life); betwe Lord and Lady Kelvin is seen Euge Griffin (A'90); between Mr. Tra and Mr. Mills is seen Dana S. Gree (A'93); behind Professor Thoms and to his right is Jesse R. Lovej (A'91, M'24, F'13, member for lif behind Mr. Trask and to his rig (third row) is Edward M. Hewl (A'91, F'17, member for life). Fi of these members are living.

(Kelvinator Corp. photo)

Early Headquarters of the Institute

By Gano Dunn, President A.I.E.E. 1911–12

A brief account of the early headquarters and meeting places of the A.I.E.E. is related here by a past-president who was a member of the original committee to solicit Mr. Carnegie's financial support for a new Institute building, and who acted as agent in the purchase of the Latimer Clark Library which was presented to the Institute in 1901 by Past-President Wheeler.

IN 1884 we were born in the house of the American Society of Civil Engineers, then a remodeled dwelling in East 23d Street, New York City. This fact and our use of the paternal mansion for some time afterward undoubtedly established the fundamentally friendly relations that have always subsisted between the electrical engineering and the civil engineering societies.

As our meetings grew larger and because in those days they usually were accompanied by experimental demonstrations in the then new electrical art, we began to use the R. Ogden Doremus Chemical Lecture Theater of the College of the City of New York across the way. It was here, as a student of the City College that I first attended Institute meetings under the presidencies of Norvin Green, Franklin L. Pope, and T. Commerford Martin.

When we outgrew the City College accommodations, we held meetings at sundry other places, some good and some bad, until we were invited by the American Society of Mechanical Engineers to share as guests the accommodations of their then new home at 12 West 31st Street, a remodeled fine old brownstone residence.

The rapid growth of the Institute, with its increasing requirements for meetings, which at times conflicted with the meetings of our generous hosts, put considerable strain upon them and upon us; consequently, a house of our own was felt to be necessary, not only for reasons of physical accommodation, but also for reasons of prestige and society pride.

Lieutenant W. D. Weaver, ex-naval officer, electrical editor, and profound scholar, whose god was a book, quietly agitated the question, which took firm hold of the Institute's leaders in the days when Mr. Andrew Carnegie was beginning his munificent gifts of library buildings throughout the country. Through Weaver, Dr. Schuyler Skaats Wheeler, later to become president of the Institute, learned of the projected executors' sale in London of the Latimer Clark Library, then the second most important electrical and scientific library in the world, which Weaver coveted for the American Institute of Electrical Engineers. Wheeler, for whom I acted as agent in the purchase negotiations, bought this precious library, which otherwise probably would have been dispersed, and presented it in 1901 to the Institute.

In order to stimulate the movement for a house of our own, Doctor Wheeler attached the condition that a suitable building be provided for it within 5 years. Carnegie, to whom this celebrated unhoused library strongly appealed, indicated, through private conferences with Weaver, willingness to receive a committee of the Institute to ask for a building that would suitably accommodate the library, provide for its growth, and at the same time serve as the Institute's home for its meetings and other activities.

Doctor Carl Hering, then president, appointed Dr. John W. Lieb, Mr. Gano Dunn, and himself, a committee to wait on Mr. Carnegie and present the case. In this presentation, the committee included plans for restaurant features, which Carnegie did not approve because he said it made the proposed home of the Institute too much like a club, to which latter type of benevolence he was then opposed.

Mr. Carnegie expressed unusual appreciation of the Institute's plans suitably to house the Latimer Clark Library, and he immediately gave us $7,000 for the preparation and publication of a catalog describing the remarkable books it contained in order that the members of the Institute and libraries throughout the country might know its rich resources. With a twinkle in his eye he asked us to come back to him again with a modification of our plans that would leave out the restaurant facilities.

The rest of the story will be told by others—how on our report of the encouragement we had received, Dr. Charles F. Scott, Mr. Calvin Rice, and Mr. T. Commerford Martin conceived and successfully carried out the idea of asking, and how Mr. Carnegie munificently granted the request for a building that would house not only the Latimer Clark Library, but also the libraries of the American Society of Civil Engineers, the American Institute of Mining and Metallurgical Engineers, the American Society of Mechanical Engineers, and the American Institute of Electrical Engineers, all in one great building that would be a common home for these and other engineering societies, contributing by their jointure, increased respect, authority, and national usefulness to the engineering profession as a whole.

[EDITOR'S NOTE: In Past-President Scott's contribution to this issue may be found an account of the details accompanying the construction of the Engineering Societies' Building. The building was dedicated April 16 and 17, 1907, although a few meetings already had been held in the auditorium.]

Some Major Events in the Life of the Institute

By Comfort A. Adams, President A.I.E.E. 1918–19

Personal reminiscences of some major events in the life of the Institute by a past-president whose active participation in Institute affairs began 30 years ago and who, on the basis of that experience, ventures some criticisms and suggestions.

UNFORTUNATELY, or perhaps fortunately for those who are reading these reminiscences, my memory of the events involved is lacking in detail; in other words, this record will be one of major events without much of the scenery that might add considerably to the interest of the story.

I joined the Institute as an Associate Member just 40 years ago, as a young instructor in engineering. For the first 10 years I took very little part in the affairs of the Institute except to attend an occasional meeting. My earliest memory of any important event was the presentation of my first paper which was entitled "The Heyland Machine as Motor and Generator," in May 1903. This paper was the result of a long summer's work in the laboratory, and apparently it marked the demise of the Heyland machine, at least as far as the United States was concerned. Perhaps the treatment was too thorough. In any case, the study had been a very interesting one and one in which I was so absorbed at the time that I could not appreciate the lack of interest on the major part of the audience. My chief recollection of the discussion was a somewhat caustic remark by President Scott, who was presiding, to the general effect that a college professor was trying to tell all he knew about the subject. In those days papers were less numerous and there were no restrictions as to the time of presentation.*

At the annual convention of 1905 at Asheville, I presented what was probably my best Institute paper, entitled "The Leakage Reactance of Induction Motors With Special Reference to Design." At least this paper attracted more attention and received more recognition on both sides of the Atlantic than any of the others, and I have every reason to believe that it was a substantial contribution to the science of induction motor design. In connection with the discussion of this paper I remember distinctly the criticism of some of the designing engineers to the effect that the methods outlined were all right for a college professor, but too cumbersome for the designing engineer. These criticisms, however, were completely canceled in my own mind by the generous approval of Doctor Steinmetz who said in effect that the designing engineers would have to use more thorough methods of analysis in the near future. From this time on I not only attended most of the annual conventions, but also began to participate actively in Institute affairs.

Although I presented later a considerable number of other papers which were received favorably, they do not stand out quite so vividly in my memory as the earlier ones mentioned. Moreover, the Institute itself began to mean so much more to me than just a place to read and discuss papers, however interesting and valuable that part of the Institute activities may be. I began to feel myself a member of a large family and to count the friendships made during that period among the happiest of my whole career.

Early Standardization Work

In 1910 President Jackson appointed me chairman of the standards committee and this was the beginning of my official participation in Institute affairs. At this point it may be interesting to give a brief account of the background of the standardization work of the Institute, as the standards committee had been in existence only 2 or 3 years. Prior to the initiation of this work, there was no accepted definition of the rating of an electrical machine. A motor was labeled 10 hp or a generator 100 kw, largely at the option of the manufacturer, without any accurate definition of what the rating meant. The result was, for example, that motors labeled 10 hp and made by different manufacturers might differ as much, according to our present ideas of rating, as between 10 hp and 15 hp. In fact a common argument of the salesman was to the effect that his motor would carry a larger overload than that of his competitors. On this account the need for standardization was apparent to many of those concerned, and the standards committee of the Institute was organized in 1907.

For several years after my first connection with this committee, I was either chairman or secretary and my most active memory of real work for the Institute was in connection with that service. I counted it also a great privilege to have been intimately associated in this work with men like Steinmetz, Lamme, Kennelly, Crocker, Scott, Skinner,

*Past-President Scott's version of this is as follows: "The Meeting notice read: 'May 19. Annual meeting. Announcement will be made regarding the proposed union engineering building and formal action by the Institute will probably be taken. It is expected that letters from some of the past-presidents regarding the project will be read.' There were letters from Edison, Kennelly, Hering, Anthony, Sprague, Thomson, and J. G. White. Resolutions were to be passed. It was to be a historic event. The program opened with 3 papers for which cautionary time signals worked properly for Behrend's paper on alternator regulation and Garfield's on alternator compounding; but the time relay on Adams' paper didn't function and the Heyland motor wouldn't stop. The paper was 50 pages in length. The president was more concerned with birth of the building than with the mortuary exercises that 'marked the demise of the Heyland machine.' Professor Adams' present statement indicates the remarkable restraint of the presiding officer in the suppression of his real feelings."

Hobart, Robinson, Burke, Cox, Merrill, Robins, and many others, the neglect to mention whom means no lack of appreciation of their work.

Although it would be very pleasant to tell more of the very interesting and sometimes difficult work done in the early days of standardization, I understand that 2 other past-presidents (Kennelly and Skinner) have been specifically assigned to discuss 2 different phases of this subject.

In 1912 I was elected as a manager of the Institute and from that time on served as a member of the board of directors for 8 years as follows: for 3 years as manager, for 2 years as vice-president, 1 year as president, and 2 years as junior past-president. If my memory for details were better, I could give some very interesting accounts of some of the good fights we had on the board, but suffice to say that I count these as among the most interesting years of my life.

Although I have served on many other committees of the Institute, the one that stands out most prominently, next to the standards committee, is the Edison Medal committee of which I was chairman for several years.

Growth of American Standards Association

Through my connection with the Institute I became connected with a number of joint activities of engineering societies which came into being within the period of my connection with Institute affairs and which now make up a very important part of our service to the profession.

After a few years of work on the standards committee, it became obvious to some of us that, owing to the inevitable overlapping of the standardization work of the several engineering societies, a coördinating body was necessary in this field. As a result of this conviction, and at the invitation of the president of the Institute, a meeting of representatives of the 4 national societies of civil, mining, mechanical, and electrical engineers and of the American Society for Testing Materials was called for January 17, 1917. At this meeting a preliminary plan of organization was presented, largely the work of Mr. H. M. Hobart, and it is interesting to note that with the exception of scope the present organization of the American Standards Association follows very closely the lines of this original plan.

I was chairman of the organization committee and could tell a long story of the struggles involved in its work, including the removal of fear, petty jealousies, and prejudices from the minds of those involved. Suffice to say that it took nearly 3 years to get the approval of the 5 original societies to a plan of organization for the American Engineering Standards Committee, as it originally was called.

I was first chairman of this committee and often compare in my own mind the small beginnings with the present American Standards Association into which it has developed. Also I have often compared the process of evolution of such a relatively small job of coöperation with that larger job of the coöperation of the nations of the world, which cannot go on much longer without a really effective mechanism of coöperation. My work in connection with the organization of this movement was one of the most instructive activities of my whole career, and I could easily expand in my reminiscences thereof, but I understand that past-president Skinner has been assigned specifically to that task.

Joint Engineering Activity in the World War

A very important though transient joint activity was in connection with the great war. The offer of the services of the engineering societies to the government was accepted by President Wilson who appointed as members of the general engineering committee of the advisory commission of the Council of National Defense, 2 representatives of each of the 4 principal national engineering Societies, these representatives being in every case presidents and past-presidents.

This committee started out under the chairmanship of Dr. Hollis R. Godfrey, who had drawn up very comprehensive plans for the mobilization of the industrial and economic life of the United States during the war. Although this plan was marvelous in its comprehensiveness, and would have been wholly satisfactory from Mr. Stalin's point of view, it was altogether too idealistic and comprehensive to be introduced overnight in a country with our traditions.

After considerable discussion we decided to look for some more limited and feasible scheme of serving the government and in June I presented a plan which was the outgrowth of my experience in standardization. At this time Dr. Godfrey resigned as chairman of the committee and I was elected in his place. As space does not permit a description of this plan, I will merely say that it was presented to the Council of National Defense, that parts of it were put into force, and that just before the close of the war General Goethals started to put other provisions of this plan into effect as far as the government end was concerned.

One of the most interesting problems presented to the General Engineering Committee was in connection with the manufacture of anchor chain, the production capacity for which in this country was utterly insufficient for the needs of the Emergency Fleet Corporation. This problem was solved largely through the generosity and coöperation of the General Electric Company by the development of a cast steel anchor chain which was distinctly superior to the old wrought iron hand-forged chain, and which could be produced rapidly in any desired quantity.

Another activity that was the outgrowth of the General Engineering Committee was the application of electric welding to the shipbuilding program. In this connection the Emergency Fleet Corporation requested the organization of a special welding committee with myself as chairman. This committee was in existence a little more than one year; and although it did not exactly revolutionize the welding industry, it saved the government at least a million dollars in the Hog Island program alone and also succeeded in developing an appreciation of research work in welding as well as a spirit of coöperation

throughout the welding industry. This spirit and appreciation have been continued through the medium of the American Welding Society and its research branch, the American Bureau of Welding, both of which were the direct outgrowth of the welding committee of the Emergency Fleet Corporation.

Other Joint Engineering Activities

Another joint activity of the engineering societies is the American Engineering Council which takes care of the nontechnical service engineers can render to the country. Herbert Hoover was the first president of the council and I was a member during its early years.

The joint activities of the engineering societies in the research field are handled in part by the Engineering Foundation and in part by the engineering division of the National Research Council. These 2 organizations are closely allied; in fact, the Engineering Foundation helped materially in the financial support of the engineering division of the Research Council for many years. I was chairman of the engineering division from 1919 to 1921.

The John Fritz Medal Board is made up wholly of past-presidents of the engineering societies. I served as secretary of the board for one year and as president for one year and awarded the medal to Orville Wright.

I have described briefly these joint activities not only because my participation therein resulted directly from my connection with the Institute, but also because they constitute a rapidly increasing portion of the services of the Institute to the engineering profession.

Some Criticisms and Suggestions

If I were asked to criticize the activities of our engineering societies, I certainly would present as my first and major criticism the general messiness of their organization and a serious lack of coöperation resulting often in serious delays in important movements. As a matter of fact, attempts have been made on several occasions during the past 15 or 20 years to reorganize our engineering societies along the lines of the more consistent and rational system employed by our German colleagues.

It is easy, of course, to explain how our present organization grew up in the mushroom fashion, and the coöperative or joint activities mentioned have been designed to reduce the overlapping and confusion of effort in fields where the confusion was so great as to make it absolutely necessary. However, there still remains a considerable number of overlapping activities resulting not only in duplication of effort and inefficiency, but also in a situation that makes it necessary for many engineers to become members of a large number of societies. It would be easy to go into detail on this subject, but this is hardly the place to do more than mention it.

There is one very delicate subject involving not only the affairs of the Institute but of other engineering societies, which I approach with considerable diffidence, namely, the corporation influence in the conduct of the work of these societies. From time to time outsiders and sometimes insiders have criticized the administration of our engineering society affairs on this basis. It just happens that I have probably had as good an opportunity as any to know what these influences have been; and I am glad to put on record here the conviction that although at times there were indications of mild efforts on the part of corporation representatives to modify our constitution and by-laws so as to make corporation influence more easily applied (for example, in the election of officers), these efforts usually failed and left our Institute as free from corporation bias as could possibly be expected under the existing economic order. As a matter of fact, the number of corporation officials or employees who have any tendency toward bias in this connection constitute an absolutely negligible portion of the Institute membership. Moreover, as I am a member of nearly all of the other engineering societies and am fairly intimate with their administration, I feel sure that the same thing can be said for them. On the other hand, there are some so-called professional societies not included in our "Founder" group of which the same statement could not be made with equal force.

Electrical Engineers and Economic Problems

A very common and long-standing criticism of engineers is to the effect that they are too narrow in their interests and do not take sufficient part in the broader public affairs of the nation. This criticism is no longer valid in anything like the degree that it was 20 years ago. I still think, however, that our own Institute perhaps has been peculiarly lacking in this respect, particularly if we are to judge by the contents of our Transactions. These same Transactions present a wonderfully fine record of the scientific and technical development of electrical engineering; but as compared, for example, with the *Proceedings* of the American Society of Mechanical Engineers, they are distinctly lacking in papers or addresses dealing with the broader and even more important economic and social problems.

It is a fact often pointed out that the training of the engineer is such as to develop the habit of sound and unbiased logic. This is particularly true in the case of the electrical engineer whose problems are solved more often by analytical methods of a fairly scientific type than is true of engineers in any other branch. Assuming this to be the case, there is no reason why this same type of unbiased logic should not be applied by the electrical engineer to the solution of the broader problems mentioned.

My presidential address delivered in June 1919 took for its subject "Coöperation"; in the light of recent events it may be of interest to quote one paragraph:

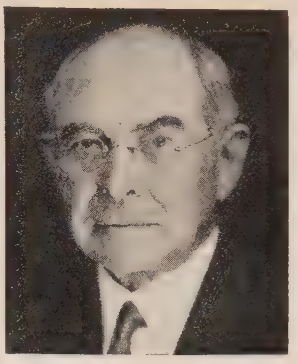
> "I do not propose any revolutionary program, but merely the hastening of the natural evolutionary development by the application of a little perspective and common sense. This does not involve altruism except in so far as a vision reaching somewhat beyond the end of one's nose may be considered altruistic. It is merely a step forward, a step of progress, which may prevent our being forced into some revolutionary stride which is doomed to failure and can mean only destruction and disaster as long as it endures."

A Century of Progress in 50 Years

By E. W. Rice, Jr., President A.I.E.E. 1917–18

Although now celebrating only the fiftieth anniversary of its founding, the Institute "has a record of accomplishment that would have done justice to a life of 100 years."

IT does not seem possible that the Institute is only 50 years old. It has a record of accomplishment that would have done justice to a life of 100 years. So the golden milestone reached this year affords a natural occasion for noting the remarkable growth and the profound progress which have come to pass since the A.I.E.E. was founded.



Fifty years ago the electrical industry was a very young infant, indeed. Yet so lusty was it that the enthusiastic pioneers of the day thought that electricity deserved an exhibition all its own. Philadelphia seemed a fitting place and therefore, under the auspices of the Franklin Institute, founded by Benjamin Franklin, the patron saint of electricity, the first all-electrical exhibition of all time was celebrated there in the year 1884.

Only a few years before, in 1876, at the Centennial Exposition held also in Philadelphia, I saw for the first time an electric light and an electric motor. It was probably the first time in the United States that the electric dynamo was shown in operation to produce light and power. Aside from the electric telegraph, which was an important commercial electrical activity even in 1876, a few dynamos used for electroplating, and batteries for the operation of electric bells, constituted about all there was to be seen of the electrical industry at that time.

A year or so later, Charles F. Brush, in Cleveland, started the manufacture and sale of his arc lighting system. Elihu Thomson, in Philadelphia, invented his famous 3-coil arc dynamo with automatic regulation; and in Menlo Park in 1879, Thomas A. Edison produced the first incandescent lamp and the multiple system of electric generation and distribution. Thus, a few years after 1876 (less than a decade, in fact) saw most of the inventions made upon which the present electric power and light industry has been founded.

The years immediately following were so prolific that at the all-electric exhibition of 1884, which I have mentioned, electric dynamos, lamps, motors, and electric measuring instruments of various kinds, the inventions of Edison, Thomson, Weston, and others, were shown by the many manufacturing companies already formed to introduce such products to the public. This exhibition was well attended by an interested and even enthusiastic public.

Bell's electric speaking telephone, first shown in 1876 at the Centennial Exposition in Philadelphia, by 1884 had been adopted rather extensively in large cities, and had become an important factor in the electrical industry.

The electric trolley was, as yet, commercially unknown in 1884. Van Depoele and Sprague, Bentley and Knight, and other inventors were just making their first tentative experiments in the application of electricity to the propulsion of street cars.

While I was personally acquainted with many of the electrical pioneers, Bell, Edison, Brush, Sprague, Van Depoele, Sperry, Weston, Stanley, and others, it was my particular good fortune to be intimately associated with Elihu Thomson. I was educated under him at the Central High School in Philadelphia, and after graduation in 1880, went from Philadelphia to New Britain, Conn., as his assistant, and in 1883 moved from New Britain to Lynn, Mass. In 1884, the year that witnessed the beginning of the A.I.E.E., we were actively promoting the arc light system of Professor Thomson through the medium of the Thomson-Houston Company. This company sent samples of its products to the Electrical Exhibition in Philadelphia, and I had much to do with the exhibit.

It is of special interest to note that at the same time and place, our newly founded American Institute of Electrical Engineers held one of its first meetings. At the very first session at which papers were read, there was a brief discussion led by the late Prof. Edwin J. Houston, on the "Edison effect," the discovery of which had been announced the previous year. Other subjects, at this and following meetings, dealt with underground wiring, the experimental testing of dynamo machines, the patent protection of electrical inventions, secondary battery plants, and telegraphic and telephonic progress. Such discussions, which became constantly more important and profitable, spurred electrical progress.

It was high time that the Institute was founded, as the scattered "electricians," as we called ourselves in those days, needed the inspiration that comes only from association of people of similar interests and like minds. In those early days the pioneers were so busy with their daily work that little time could be spared to attend meetings. However, even if meetings were sparsely attended, the organization formed a nucleus which steadily drew to itself earnest electrical workers in all parts of the country. It became the recognized meeting place, the forum, the clearing house of electrical ideas, and eventually the authority for such standardization, technical and professional, as was needed in a rapidly expanding art.

I believe that the realization of the value of scientific methods perhaps was greater in the electrical industry than in the older and well established enter-

prises. There was a close connection between the universities and technical schools and the electrical industry, even in its earliest days. The novelty and highly technical nature of our problems led those of us who were in charge to draw upon the colleges and universities for graduates trained in such scientific and technical knowledge as then existed. These new, eager, young men were set to work in the engineering and testing departments, and those of special aptitude were given opportunity to assist in the research necessary to a new industry.

History shows that progress often has been dependent upon the energy and genius of some individual. In the future, advances undoubtedly will come in the same way; but we believe that more frequently the best progress will follow the use of organized research based upon coöperative efforts of many men in universities, industrial organizations, and national institutions.

In all this work the A.I.E.E. has occupied a commanding position. This has been true during the past and will continue to be true in the future. I am glad to testify that my faith in the value of the Institute was definitely increased during the term I was privileged to serve as president. The spirit of coöperation and of broad interchange of fundamental knowledge which it has fostered, has been invaluable. In common with other scientific societies, the Institute has inculcated a spirit of unselfish service to its members and to all mankind.

Science is international; its field is the world; information is freely exchanged; there is no tariff on scientific ideas; progress therefore is based upon the contributions of all workers in every civilized land.

I extend my heartiest felicitations to the Institute on this occasion of its golden jubilee. In common with those others who have served as its president, I wish for the institution a long and useful future. May its contributions to the progress of our profession during the next 50 years, if possible, exceed those it has rendered during the half century that is just closed.

A Group of Those Attending the 15th Annual Meeting, Boston, Mass., 1899

Those in the picture are, left to right, bottom row: (?), A. V. Garrett, S. E. Doane, R. W. Pope, W. L. Puffer, C. P. Steinmetz, Elihu Thomson, and W. J. Hammer. Second row: H. E. Clifford, (?), H. Ward Leonard, W. E. Goldsborough, William Brophy, A. E. Kennelly, and E. A. Sperry. Third row: W. L. Smith, (?), W. S. Aldrich, H. J. Ryan, (?), Joseph Wetzler, and (?). Fourth row: C. M. Bigelow, (?), (?), H. B. Coho, (?), W. D. Weaver, G. F. Sever, (?), Louis Bell, (?), and (?). Top row: (?), and A. L. Clough.

The Equation of Electrical Propagation

By M. I. Pupin, President A.I.E.E., 1925–26

Members of the Institute always have been interested primarily in those parts of electrical science that concern the motion of electricity in conductors. Although Kirchhoff and Maxwell formulated the equations of electrical propagation more than 30 years before the founding of the A.I.E.E., it remained for the period coinciding with the life of the Institute for the full meaning of their theoretical achievements to be demonstrated. It seems particularly appropriate, therefore, that on the Institute's 50th anniversary these achievements should be reviewed by one who has had such a large part in applying them and in extending them to long distance telephonic transmission.

THE Semicentennial celebration of the American Institute of Electrical Engineers is a fitting occasion for a review of the many advances which during the last 50 years have been achieved in the science and in the art of electrical engineering. This art, like every art, is long and it will take many a skilled electrical engineering artist to draw a picture that will display adequately these advances in the electrical engineering art. I am not one of these artists; I am only an amateur of this art. Hence, my brief story will confine itself to a description of one only of the many advances on the purely scientific side of electrical engineering during the lifetime of our Institute. This advance relates to the mathematical theory of electrical transmission for telegraphy and telephony.

I cannot introduce my story better than by mentioning briefly the foundations that Faraday and Maxwell laid to the electrical engineering science. We all understand today the full meaning of the laws that Maxwell, summing up the discoveries of Oersted, Ampère, and Faraday, formulated as follows; call them Maxwell's laws:

"The rate of variation of the magnetic flux through any area is proportional to the electromotive force generated by the varying flux along the boundary curve of that area.

"The rate of variation of the electric flux through any area is proportional to the magnetomotive force generated by the varying flux along the boundary curve of that area.

"Flux and force of the same type are proportional to each other in ideal insulators."

An Important Chapter in Electrical History

To the concepts *electric and magnetic flux* is connected one of the most important chapters in the history of electrical science. These concepts were born in the mind of great Faraday, and they were nursed and made strong by the genius of Faraday's most distinguished pupil, Maxwell. According to these 2 prophets of science, electric and magnetic flux represent the electromagnetic energy of the electromagnetic field. Where these fluxes are, there is electromagnetic energy; and the variation of the fluxes in any part of space means that electromagnetic energy is moving from one part of space to another, along the paths mapped out through space by the fundamental laws just quoted. Maxwell's equation of electromagnetic energy propagation shows the way of these paths; but the full meaning of Maxwell's equation of energy propagation was not revealed to ordinary mortals until Hertz published the results of his classical experiments in 1888. At that time our Institute was only a youngster, barely 4 years old; but since then the education of this youngster has grown almost as rapidly as the fame of Maxwell's electromagnetic theory which predicted the motion of the electromagnetic energy through free space. The electrical engineer has today an incomparably deeper understanding of this motion than he had 50 years ago. The young radio art of today is his best interpreter of Faraday's and Maxwell's speedy energy flux. I shall now examine briefly the background of the electrical theory that preceded Maxwell.

Our Institute is an institute of electrical engineers. Its members always were interested primarily in those parts of the electrical science that concern the motion of electricity in conductors. Their interest in the motion of the electric and magnetic flux through free space and through insulators as predicted by Maxwell's theory is of more recent date, and it was stimulated by the modern achievements of the radio art. It is fitting, therefore, that on the occasion of the semicentennial celebration of our Institute a word or 2 be said concerning the history of the achievements of that part of our science which during the last 50 years succeeded in solving several of the theoretical problems of the motion of electricity in conductors, and thus inaugurated a great advance in the telegraphic industries.

Discoveries of Ohm and Joule

One cannot look back to the earliest days of this history without seeing at the very first glance the illustrious names of Ohm and of Joule. The laws

discovered by them are the earliest disclosures of quantitative relations between electrical forces and electrical motions in conductors. The advancement of the electrical science since the discovery of these 2 laws over 90 years ago suggests a more up-to-date terminology in their statement. It can be shown that a change in the terminology of the electrical theory was inaugurated by Maxwell nearly 80 years ago. The principle of conservation of energy, still unknown in the days of Ohm and Joule, suggest the following more modern form of statement of Joule's law:

"The heat energy generated per unit of time by a constant current between 2 points on a linear conductor is equal to the product of the current into the electrical reaction of the conductor."

The term "electrical reaction" which appears in this statement was not known in Joule's time. The word "reaction" is a familiar term in Newtonian dynamics. Electrical reaction is, of course, a force in the overcoming of which the current generates heat. Joule's law makes this force equal to the product of current and resistance; call it *resistance reaction*. But Ohm's law says that this resistance reaction is equal to the difference of potential between the 2 points on the linear conductor. This potential difference is the moving force, or, employing Newton's terminology, we can call it the electrical action; and then Ohm's law can be stated in the following Newtonian form:

"In a constant current between 2 points on a linear conductor the electrical action is equal to the electrical resistance reaction."

It is a small step, only, from this simple case of electrical motion studied by Ohm and Joule to the general case of any electrical motion in the simple circuit consisting of a linear conductor under the action of any electrical forces. The principle of conservation of energy makes it obvious that:

"In every motion of electricity between 2 points on a linear conductor, the sum of electrical actions is equal to the sum of electrical reactions."

Call this *the generalized form of Ohm's law*. The terminology it employs exhibits clearly the similarity between *electrodynamics* and Newtonian dynamics. This similarity was the guiding light to Maxwell when he started out to interpret Faraday.

Ohm's studies which led him to the formulation of his law of electrical motion were confined to the motion of electricity in a simple circuit consisting of a linear conductor in which a constant electromotive force sustained a constant current. The next step in the growth of our knowledge of the motion of electricity in conductors was the study of this motion in complex circuits of linear conductors. This step was made in 1848 when Kirchhoff published his historical essay on the motion of electricity in a network of linear conductors in which constant electromotive forces were impressed upon the various branches of the network. He deduced the following historical formula:

"In every closed circuit of a network of linear conductors carrying constant electrical currents the algebraical sum of the products of the currents into the respective resistances of the branches of the circuit is equal to the algebraical sum of the electromotive forces impressed upon these branches."

This formula often is called Kirchhoff's law. I prefer to call it Kirchhoff's rule. It is a mathematical deduction from Ohm's law. Kirchhoff was using Ohm's language; if he had employed the concepts and the terminology suggested by the principle of conservation of energy, he probably would have called "the products of the currents into the respective resistances of the branches of the circuit" the resistance reactions of these branches; and then he could have stated his rule as follows:

"In a network of linear conductors carrying constant electrical currents the algebraical sum of the resistance reactions in any closed circuit of the network is equal to the algebraical sum of the electromotive actions impressed upon that circuit."

Kirchhoff's "Rule" Reveals Energy Relations

In this form Kirchhoff's rule is not a mere algebraical formula deduced from Ohm's law; it reveals energy relations which Ohm's law does not reveal, and it shows that even in a complex circuit which is a part of the network of linear conductors Newton's law of equality of action to reaction is applicable. It supplies an additional illustration of the similarity of electro-dynamics to Newtonian dynamics.

When Kirchhoff's rule is stated in the form just given then its generalization is obvious. If according to the generalized form of Ohm's law, which I mentioned before, the motion of electricity between 2 points on a linear conductor makes the sum of electrical actions equal to the sum of electrical reactions, then, applying this equality to every branch of a circuit in a network of linear conductors, the following energy relation easily is deduced:

"In every circuit in a network of linear conductors the sum of electrical actions is equal to the sum of electrical reactions."

This relation I call Newton's third law of motion of electricity in a network of linear conductors. To call it Kirchhoff's law, as often is done, is certainly misleading. When Kirchhoff published his rule in 1848 the energy principle was still a stranger among physicists. Kirchhoff was not aware of its existence and he could not at that time translate his rule into the language of this principle. Ten years later, however, he was much wiser, and in his epoch making essay of 1858 he applied correctly Newton's third law to the motion of electricity in a linear conductor. In this essay on the propagation of electrical signals over a telegraph wire suspended high above the ground, he felt his way cautiously and finally he recognized that the sum of the inductance and resistance reaction in every element of the telegraph wire is equal to the potential difference between the terminals of the element. He gave expression to what I have called the generalized form of Ohm's law. Kirchhoff did not call it the law of equality of action and reaction; but it was that, and it led him to the equation of propagation of electrical signals over a telegraph wire. This is the famous telegrapher's equation which ever since that time was the guide of telephone and telegraph engineers. Maxwell's equation of propagation of the electric and magnetic flux through free space is, and it should be, practically identical in form with Kirchhoff's equa-

tion of propagation of telegraphic signals over a telegraph wire. Each one of them results from the actions and reactions in the tiny volume element of the electromagnetic field and each exhibits a propagation of transverse waves, and both give a velocity of propagation that is practically the same as the velocity of propagation of light.

I always wondered how so brilliant a mind as that of the late Oliver Heaviside could fail to appreciate Kirchhoff's essay of 1858. Maxwell mentioned it in 1865 in his communication to the Royal Society in which he announced his great *electromagnetic theory*. Heaviside does not seem to have seen it until much later, and when he saw it he did not hesitate to speak lightly of it. Perhaps he, at one time a telegraphist by profession, was somewhat disappointed that a German professor who knew very little of the telegrapher's art anticipated him in the discovery of the telegrapher's equation.

Maxwell Reduced Relations in Electromagnetic Field to Newton's Law

In my Steinmetz lecture (*Science*, July 10, 1925) I pointed out how Maxwell, a faithful disciple of the energy doctrine, reduced the dynamical relations in every part of the electromagnetic field to Newton's law of equality of electromagnetic actions and reactions, and I said:

"The possibility of describing electrical phenomena in terms of Newton's concepts and language is one of the greatest achievements of Faraday and Maxwell."

In that lecture I laid particular stress upon the actions and reactions with which Maxwell's genius endowed the tubes of flux in insulators and in free space. In my present sketch I have endeavored to lay particular stress upon the law of equality of actions and reactions which control the motions of electricity in conductors. Kirchhoff's equation of propagation over a conducting wire is the crown of the theory of these motions just as Maxwell's equation of propagation is the crown of his dynamics of the electromagnetic flux. Kirchhoff's equation preceded Maxwell's by a few years, but Maxwell's equation of propagation cannot be considered in any sense as an extension of that of his predecessor. The 2 belong to 2 different worlds of electrical science, and Maxwell's world was the new world which Kirchhoff never entered.

It may be of some historical interest to record here that Kirchhoff himself was not aware of any contacts between his mathematical researches in the science of electricity and Maxwell's electromagnetic theory. The following quotation from my autobiography ("From Immigrant to Inventor," p. 233–34) throws some light upon this point:

"Gustav Robert Kirchhoff, the famous discoverer, formulator, and interpreter of the science of spectrum analysis, and the founder of the theory of radiation, was at that time (the winter term of 1885–86 when I was student at the University of Berlin) professor of mathematical physics at the university. He was considered the leading mathematical physicist of Germany. His contributions to the electrical theory occupied a very high place. The most important of these was undoubtedly his theory of transmission of telegraphic signals over a thin wire conductor stretched on insulated poles, high above the ground. It was a magnificent mathematical analysis of the problem, and it showed for the first time that theoretically the velocity of propagation of these signals along the wire is equal to the velocity of light. The university catalogue announced that he was to deliver a course of lectures on theoretical electricity during the first term of my residence at the university. I attended the course and waited and waited, but waited in vain to hear Kirchhoff's interpretation of Faraday and Maxwell. At the close of the semester the course ended and the electromagnetic theory of Faraday and Maxwell was referred to on 2 pages only, out of 200; and the part so honored was not, even according to my opinion at that time, the essential part of the theory. In this respect the lectures were disappointing, but nevertheless I was most amply rewarded for my pains. I never heard a more elegant mathematical analysis of the old school electrical problems than that which Kirchhoff developed before his admiring classes. That was the last course which he delivered; he died in the following year, and was succeeded by Helmholtz as temporary lecturer on mathematical physics."

In 1888, Max Planck, the discoverer of the quantum theory became Kirchhoff's successor. It was tragic that Kirchhoff's life was not spared a few months longer so as to permit him to witness in 1888 the triumph of his favorite pupil Hertz.

Early Engineers Paid Small Heed to Kirchhoff's and Maxwell's Achievements

Fifty years ago when our American Institute of Electrical Engineers was founded the *electrical theory* was practically in the same condition in which Kirchhoff and Maxwell had left it nearly 30 years earlier; but the electrical art had advanced much during the 3 decades following the publication of their epoch making equations of propagation. The transatlantic cable had been laid, dynamos were supplying electric energy for lighting and power, and the telephone was gaining rapidly its well deserved popularity. The engineers who guided these new electrical arts, however, paid small attention to Kirchhoff's and to Maxwell's theoretical achievements. I am inclined to believe that many charter members of our Institute knew the work of these 2 great scientists by hearsay only. It was reserved for the period coinciding with the life of our Institute to demonstrate the full meaning of Kirchhoff's and of Maxwell's equations of propagation.

The radio art describes more eloquently than any pen can do what Maxwell's electromagnetic theory has done for the transmission of speech and music, and even of living pictures across oceans and continents. Every schoolboy knows today that these messages are carried on the wings of the electrical waves the existence of which Maxwell's theory had prophesied 70 years ago. The birth of this radio art is certainly the greatest event in the electrical engineering world that our Institute has witnessed during its semicentennial existence; but here I must leave the thrilling story of this great achievement of electrical theory to some radio scientist whose pen is wiser and more skilled than mine.

Long Distance Telephonic Transmission

I shall pass now to another art which also may be said to have been born during the lifetime of our Institute. It is the art of the long distance telephonic transmission over conducting wires. Just as the radio art is an offspring of Maxwell's equation of propagation so the beginnings of long distance tele-

phonic transmission can be traced to Kirchhoff's equation of propagation over conducting wires. We all know how difficult it was 50 years ago to operate Bell's beautiful invention over distances longer than a few miles. The difficulty seemed insurmountable whenever an attempt was made to carry out this operation over telephone cables. The so-called practical engineer was helpless. Kirchhoff's equation of propagation was ready to teach him, but he did not understand its language. There was one word in the vocabulary of this language that he refused to learn. That word was "inductance."

The telegraph engineer of those days had a holy horror of the so-called "choak coils" in the telegraph line; the telephone engineer inherited that fear, and hence he paid small attention to the apostles of the inductance doctrine. The foremost among these apostles was the late Oliver Heaviside. The beneficent action of inductance was evident in Kirchhoff's equation of propagation, because it starts from the generalized form of Ohm's law which says, that in every element of the telegraph wire the sum of the inductance and the resistance reaction is equal to the action of the potential difference between the terminals of the element. This potential difference is the driving force that overcomes the conservative inductance reaction and the dissipative resistance reaction; hence, the greater the first in comparison with the second, the less energy will the propelled electrical wave lose in its passage over the transmission wire. On this point Kirchhoff's equation of propagation, interpreted in the light of the energy principle, was explicit. There was no great need of eloquent apostles of the inductance doctrine. Kirchhoff's equation of propagation was just as eloquent as any of the later apostles of this doctrine; but there was a need of a theory that could tell the telephone engineer how to design a telephone conductor having a sufficiently high inductance and a sufficiently low resistance. The telephone cable waited anxiously for such a theory. The late Oliver Heaviside, in spite of his veritable flood of mathematical essays advocating high inductance in long distance telephonic transmission, failed to furnish an equation of propagation over conducting wires which could tell the telephone engineer more than Kirchhoff had told him.

It was recognized generally that a new electrical transmission structure was needed and a new equation of wave propagation over such a structure. The writer of this story was fortunate to invent such a structure, and to discover a mathematical theory of wave propagation over it which gave the telephone engineer a trusty guide in all future designs of telephonic transmission conductors having as high an average inductance as may be desired. This theory was first communicated to our Institute 34 years ago, and the epoch making advancement which it inaugurated in the telephonic art is certainly one of the memorable events in the life of our Institute. The new structure, as well known, is a telephone conductor with inductance coils inserted in it at periodically recurring points, the distance between them obeying a rule prescribed accurately by the equation of propagation over such a structure. This equation of propagation was born during the lifetime of our Institute. Those of Maxwell and Kirchhoff were handed down to it from the days when the electrical theory was still young. Our Institute was fortunate to witness during its semi-centennial existence the rise of splendid electrical industries which trace their origin to these 3 equations of electrical wave propagation.

"Pupinized" Conductors

The youngest equation of electrical wave propagation that I just mentioned is the parent of what is called in this country "a loaded conductor." When this title was applied to it in a lecture before the faculty and students of the Massachusetts Institute of Technology, 32 years ago, Dr. Henry Pritchett, who was then president of this institution, objected to the title. It reminded him, he said, of an intoxicated trolley car conductor. The audience supported heartily his objection, but nevertheless the title "loaded conductor" still persists in the Transactions of the American Institute of Electrical Engineers. Scientists outside of the United States prefer to call this new telephonic transmission structure a "pupinized" conductor. The process of building such a structure they call "pupinization" in all civilized countries outside of the country where the inventor lives and where his invention has done more good than in all the other countries of the earth put together. I am told by my European friends that the word "pupinization" is popular in Europe not only because it is a just tribute to the inventor, but also because it *denotes* a new theoretical achievement in electrical science and *connotes* a precious characteristic of the structure which is the offspring of this theory.

The new theoretical achievement is the equation of propagation over nonuniform electrical conductors and the precious characteristic of such a conductor possessing a high average inductance is the toroidal inductance coil inserted in it at periodically recurring points. Without the inductance coils having a negligibly small external magnetic field, the high inductance telephonic transmission structure described would lose most of its technical value. The word "pupinization" by connotation tells this story; the words "inductive loading" do not.

Courtesy *Bell Telephone Quarterly*

Digging in "The Mines of the Motors"

By Frank J. Sprague, President A.I.E.E. 1892–93

Some personal reminiscences of experiences in the electrical industry are recorded in this article by "the father of electric traction" who has dug in "the mines of the motors" for 3 score years. From his courageous pioneering efforts great systems of electrical transportation have grown. It is entirely fitting that these experiences, which are so interwoven in the history of the electrical engineering profession, be recorded on the occasion of the Institute's 50th anniversary by a past-president whose entrance into the profession antedates the Institute by a decade.

In a reminiscent survey of the modern industrial revolution I am reminded of the prophetic utterances of a former commissioner of patents, Thomas Ewbank, in his report for 1849, the year of the great California gold rush, from which some brief excerpts are given in the following paragraphs. On the subject of "Electric Motors":

> "The belief is a growing one that electricity, in one or more of its manifestations, is ordained to effect the mightiest of revolutions in human affairs. In subtlety and power, in excitability, rapidity and intensity of action there is nothing like it. Its complete subjugation may be held as a climax of conquests in art, the apex to ambition in science—so blessed and boundless, so surpassing all anticipation, are the seeming results that must follow. When, in addition to what it is now performing as a messenger—one swifter than those of the gods, and more reliable than the boasted Ariels of poets—it can be drawn rapidly from its hiding place, and made to propel land and water chariots, animate manufacturing mechanisms, become an agricultural laborer and a household drudge of all work, then we may begin to think the genius of civilization is vaulting rapidly toward the zenith."

After citing the experiments with Jacobi's boat, Davidson's first real locomotive, and various industrial applications—all dependent upon the zinc battery and the electromagnetic type of motor—he continued in somewhat pessimistic fashion:

> "But these experiments, interesting as they certainly were, have brought no marked results, nor afforded any high degree of encouragement to proceed. It might be imprudent to assert that electromagnetism can never supersede steam; still, in the present state of electrical science the desideratum is rather to be hoped for than expected. Great, however, will be his glory who in the face of these discouragements succeeds."

And then describing the rush for gold, a peroration to which there would be varying reactions in these days of social unrest and business bewilderment:

> "There is no wealth but labor—no enjoyments but which derive from it. But, to those who are ambitious of ennobling themselves and really enriching their country, *placers* inexpressibly more precious than any to be found on the Sacramento are invitingly open. Let them dig in The Mines of the Motors, and they will bring to light, active, fruitful, and everlasting sources of true opulence."

A score of years passed before Gramme brought out the first commercial dynamo electric generator, and 3 years later, at the Munich celebration of 1873, its vital characteristic of reversibility of function was demonstrated, this laying the foundation of the entire system of the transmission of power by electricity. A year later marked my transition from the life of a country boy to that of an abbreviated naval career, by way of a competitive appointment to Annapolis, and found me tarrying in New York City on my way there. I cite this date because it is so close to that of an epochal discovery, although a decade before the founding of the Institute, and because of many electrical happenings in that period.

The metropolitan population then totalled about 1,700,000. There were no telephones or electric lights, no trolleys or subways, not even an elevated railway except a short section on Greenwich Street. Automobiles, of course, were unknown, and the Brooklyn Bridge was in the early stages of construction. I little dreamed of a new era that would change the face of civilization, and that the use of electricity for industrial power and for vertical and horizontal transportation would later make me a factor in the city's subsequent enormous growth.

Naval education brought many experiences, and helped to mold my character in a fashion that contributed materially to later activities. With something of a flair for mathematics and naval architecture, and especially a love for physics, the department for which was headed by the late Admiral Sampson, I was well placed among the surviving third of my class.

Early Inventions

Following a visit to the 1876 Centennial Exhibition came the beginning of new interests, and later, impressed by the work of Bell, Gray, and Edison, a new telephone was essayed. Disciplined for first attempts, special apparatus was sought from Edison, but unable to supply it he suggested my stopping at Menlo Park on the way home from graduation in June 1878. By this time the creative urge had taken full possession, and in the following 2 years, including a period of duty on the Asiatic Squadron, while also acting as special correspondent of the Boston *Herald*, I was guilty of nearly 3 score of inventions of varied character; most of these are recorded in a much prized "Midshipman's Note Book,"

mixed with professional notes and cruise records. A duplex telephone, pocket phonograph, time fuse, quadruplex and octoplex telegraph systems, a weird motor, means for transmitting pictures by wire, gyroscopic control of the mercury horizon and torpedo direction, an electric pantograph, a multiple telescope, regulation of incandescent lights, water cooling apparatus, and control by variations of pressure on a submerged carbon disk of a ship's engines, to prevent racing with exposed propellers, are indicative of a variety of activities which were a nuisance to my shipmates. Many of these inventions were really worth while, but neither naval duties nor available money made possible their development then.

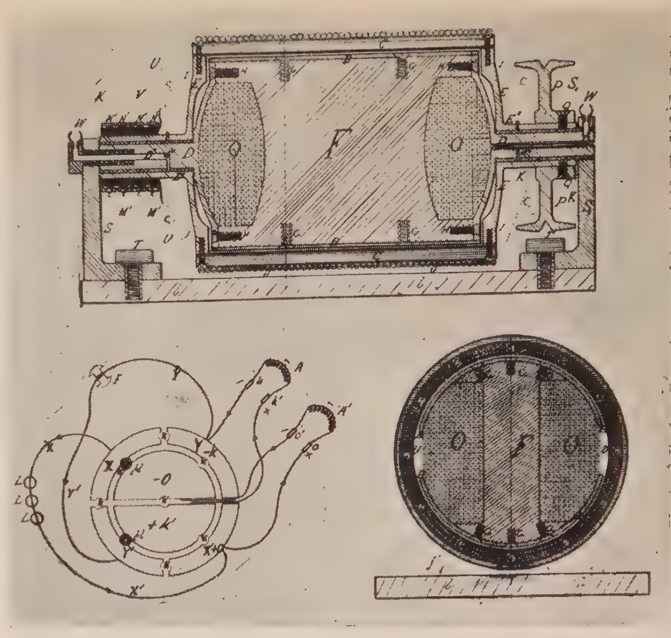
Ordered home for examination in the spring of 1880, a short leave was utilized to experiment at Stevens Institute of Technology (Hoboken, N. J.) with a new type of arc lamp mechanism, and I had the good fortune to meet that famous pioneer, William Wallace of Ansonia, Dr. Henry Draper of New York, and Prof. Moses G. Farmer, then government electrician at the U.S. Torpedo Station, Newport, obtaining from the latter reluctant approval of an attempt to construct a dynamo without a commutator to develop current at a constant potential of 100 volts, a venture that, based upon false premises, soon collapsed.

Detailed for duty to the "Minnesota," a training ship for boys in whose tuition there was little interest, I planned to light the ship electrically by using a dismantled steam pump for motive power, but the loan of a dynamo was refused on the ground of irregular motive power. Soon afterward the ship proceeded to Newport, where in the spring of 1881 I again met Professor Farmer. Here, in the interim of ship duties, the construction of a novel dynamo electric machine was undertaken.

"Inverted" Type of Dynamo and Series-Parallel Control

The characteristics of this machine, involving 2 radical departures, are illustrated in an accompanying diagram. Up to this time all dynamos comprised an external magnetic field assembly, between the poles of which the armature was rotated. In the new machine these relations were reversed, the armature being turned inside out and the coils enclosed by an outside iron shell of iron wire and inwardly projecting ribs, the whole surrounding the field magnet. Built for continuous current and with two armature circuits and commutators, the field magnet was held stationary, while the armature was rotated. This physical relation of external armature and internal field is characteristic of every modern power plant alternator. In all of these the armature, or stator, encloses the field magnet, or rotor, the latter being the moving part.

Another feature was a switch that enabled different combinations of field and armature circuits, and that illustrates the basic principle of all-series-parallel controllers used on d-c railway motors. This was invented independently at the same time by Dr. John Hopkinson of London for control of 2



Inverted type of dynamo electric machine, forerunner of the modern a-c generator; also the series-parallel combination of motor circuits

The latter also was independently proposed for 2 motors by Dr. John Hopkinson of England at the same time (1881). This model was used both as a generator and a motor

motors. Later, this machine was operated as a motor at the shop of Bergmann and Company, and the series-parallel control was used independently for both fiield and armature circuits on the St. Joseph and Richmond trolley roads in 1887, where it was referred to as an "electromechanical couple." On these equipments both change of field circuits and reversal of movement were effected on a single cylinder, while the armature changes were made by a separate switch. The latter soon was discarded because of the runaway slip of one pair of wheels when starting on a slippery track and high grade with the armatures in series. The combination also was used by Reckenzaun and Condict, and with Thompson's magnetic blow-out was developed by Potter into the widely used street car controller, by which the series-parallel and resistance sequences are effected by movement of a single handle, and the reversal by an independent switch.

Naval life being then in a quiescent stage, assignment was sought as assistant to the officer representing the Navy at the 1881 Paris Electrical Exhibition. This being refused, on the suggestion of the late Captain Howell I procured orders for temporary duty on the U. S. S. "Lancaster," then being fitted out as flagship of the Mediterranean squadron, with privilege of 3 months' leave on arrival. The ship being delayed, I installed a call bell system, the crudities of which may be judged by the character of the materials then available when subjected to sea conditions.

Too late for the Paris Exhibition, I was permitted to attend that to be held at the Crystal Palace, Sydenham, England, and arrived in London early in 1882, with about $20 and the necessity of presenting urgent needs to the U.S. Despatch Agent.

Made a member of the preferred section of the Jury of Awards, I was brought into contact with some of the leading scientists of England and experienced one of the most colorful phases of my life. Among them were: Prof. Fleeming Jenkin of the Edinburgh University; Prof. W. Gryll Adams of the Wheatstone Laboratory of King's College, brother of Charles Adams, who shared with Le Verrier the honor of locating mathematically the position of Neptune; Horace Darwin, son of Charles Darwin the naturalist; and many others. As secretary, I initiated a series of tests of gas engines, dynamos, and electric light; but having overstayed my leave nearly 6 months, with a probable court-martial in sight, I received peremptory orders to report the reasons therefor and to rejoin my ship. On arriving at Villefranche a cable authorized my remaining in London to complete my work, but I stayed aboard ship, and recorded the results in a voluminous hand-illustrated report which, happily, won the commendation of the Navy Department, with publication by the Bureau of Intelligence and praise from English technical journals. I still think it was a pretty good piece of work, and at least I escaped being disciplined. While testing gas engines the indicator diagrams at times showed evidences of advanced explosions, following which a 16-hp Otto engine was run on a forced test for about 10 minutes with the outside ignition cut off and only internal compression firing—a recorded experiment which may be considered the forerunner of the Diesel engine.

Undercontact Overhead Conductor System

During the stay in London in '82, as well as on return in the following spring, an ambition developed to equip the Metropolitan District underground railway electrically. I first planned to use as conductors the running rails and an automatically tensioned midlocated wire, or "working conductor" connected ladder-wise to a main conductor. Later I visioned the freedom of movement of a car between 2 contact planes, these being substituted by the network of running rails, crossovers, and switches, and an overhead conductor following the center lines of all, the circuit of the motors being completed through the wheels and an overhead self-adjusting upward-pressing contact. This is the forerunner of the undercontact trolley and pantograph collectors characteristic of all overhead systems using a single conductor. The undercontact, in a more limited fashion, was proposed also by Van Depoele about 1883, but in a patent interference some years later my evidence of priority abroad was not permitted, such being limited to the date of reëntrance to the United States in May 1883, despite American citizenship and duty. Because, however, of conflicting patent claims and practices, arrangements for mutual use were arranged.

Shortly before this, after passing examination for Ensign I had resigned my commission, with a year's leave, and made an agreement with Edward Johnson to join Mr. Edison as an expert assistant; but before returning home I conducted tests at Manchester on the new Edison-Hopkinson short-cored dynamo, and made a report on the savings possible on the 3-wire system, because of a difference of opinion between the independent inventors, Edison and Hopkinson, the former proving to be right. I arrived home on the day the Brooklyn Bridge opened and promptly reported to my employer, who seemed to think that a salary of $2,500 was per year unduly munificent. With W. S. Andrews I later was sent to Sunbury, Pa., with instructions to complete preparations in 48 hours to start the first overhead 3-wire system. This was put in operation on July 4, and later I was given charge of the electrical part of the first underground 3-wire system at Brockton, Mass.

At this time the sizes of the mains and feeders of the small central stations projected were determined by an actual survey of the lights and the tedious construction of a small model. One day Mr. Edison, in spite of his well-known aversion to mathematics, asked if some one could not "figure it out," and the job fell to me. I soon found that the proportions of mains and feeders adopted were wrong, and, my methods and conclusions being challenged, a layout for the city of Ithaca, N. Y., was selected for a test. I proceeded on the theory that there should be a like maximum drop of potential at the low voltage points of all mains, and that feeder resistances should be inversely proportional to the loads they had to carry. Having demonstrated the soundness of these conclusions, later patented, all determinations for a while were turned over to me and the fortnight's work reduced to about 4 hours.

Both the parent and licensee companies of the Edison system generally were known as "electric light" or "illuminating" companies, thus designating their principal activities. At Brockton I had busied myself developing an electric motor. Convinced that the use of electricity for motive power was as important as, and probably would exceed, that for illumination, I declined to take up the subject as an assistant to my employer and resigned in the spring of '84, just before the Institute was chartered, to form the Sprague Electric Railway and Motor Company. This was at first only a paper organization with a $100,000 capital structure, of which about $1,600 was sold for cash; but I had made a contract with Johnson that he would advance certain monies for corresponding proportionate interests. I was, however, a general factotum for all duties, with a self-assigned annual salary of $2,500.

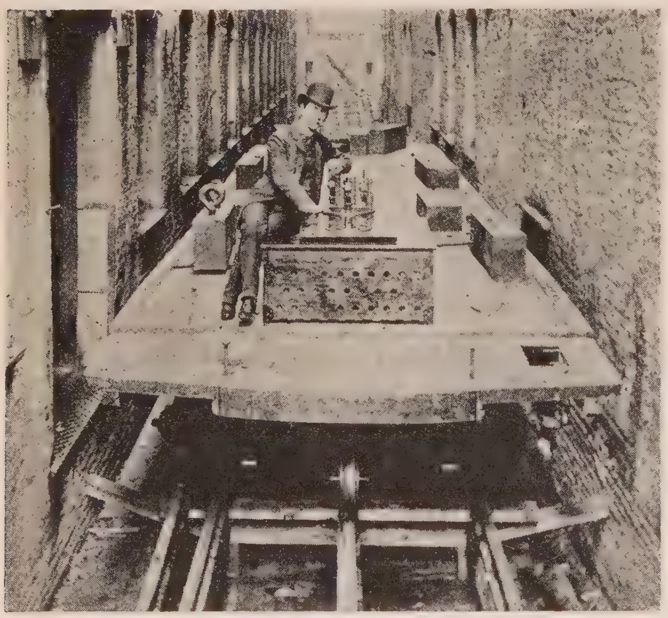
Constant Speed Motor

Our initial industrial motor development was based upon the important fact that on a constant potential circuit the mechanical effects—variations of speed and power output—of a motor could be controlled by inverse variation of the strength of the magnetic field to determine the differential of the line and motor electromotive forces; also, that with 2 magnetizing field coils, one of high resistance across the line for the main field excitation and another of few turns in opposition to it and in series

with the armature, it would be possible with certain proportions to operate a motor at the same speed under varying loads, and even different potential differences, which constant speed might also be varied—this of course a mathematical deduction. In addition, it appeared that by a distorted location of the series coil it would be possible to maintain automatically a fixed nonsparking position of the brushes under varying loads. To insure a strong field in starting, a cut-out or reversing switch was added.

This is the genesis of what was known as the constant speed motor with fixed nonsparking position of the brushes, primarily for use on constant potential circuits; and it was the first motor of this type to be put into commercial service. From the original principle enunciated there naturally followed the idea of regeneration of energy to return electricity to the supply circuit for train braking and elevator operation, the former described in a paper on a proposed equipment for the New York Elevated Railway, read at the Society of Arts in Boston in December 1885.

Production of motors was begun immediately, with exhibition of several types at the Franklin Institute Exhibition in the fall of 1884, these receiving high commendation by English and American



Platform car and truck equipped with 2 "wheelbarrow" 3-point type of suspended motors

Double drive with single reduction adjustable gearing, shunt field control, regeneration, and electric braking. Test made during winter of 1885–86 at the Durant Sugar Refinery, New York City

scientists, including Sir William Preece, Professor Sylvanus Thompson, and Mr. Edison. The holding of the exhibition was the occasion for a meeting of those interested in electrical science and its applications, and at one of them, with a vivid appreciation of the operation of gas engines gained at the Sydenham exhibition, I ventured to propose the use of a storage battery as a starter, a suggestion that met with considerable criticism. Its present day universal use in automobiles is a striking example of the unwisdom of hasty adverse judgments with regard to the possibilities of a new idea.

Commercial introduction of the constant speed motors proceeding rapidly, in May 1885 the Edison Electric Light Company issued a circular to its licensees, in which it urged the use of this motor to add to and even up output, and proclaimed it as the only satisfactory one available. A year later the Sprague company issued the first important industrial electric motor catalogue, detailing the location, and so far as available the history, of nearly 250 machines, and citing nearly 140 industries to which the electric motor could be applied. So was established a new industry which soon became commonplace in its application.

Electric Railway Development

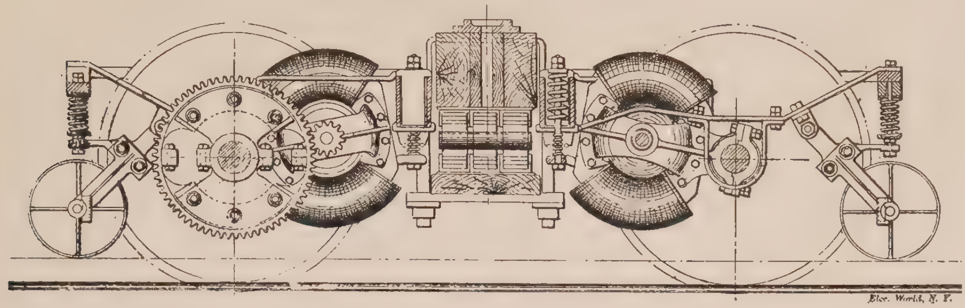
Absorbed in my work I did not join the Institute until May of 1887. Its proceedings for the first 4 years of its existence were compassed in a single volume of Transactions, but besides the application of motors for industrial purposes an active interest had developed in the matter of traction, as indicated by a general plan with colored illustration for a 4-track undergound railway for New York in a paper on "The Scientific Street" by Rowland Hazard in 1884, and 2 papers by T. Commerford Martin, one in December '86 on "Electric Street Cars," and the other in May '87 giving comparative statistics of a dozen and a half installations of varying characteristics made in Europe and the United States, from which this interesting comment may be cited:

> "In Europe, as here, various systems of transmitting the current and of connecting up the motor with the axles and wheels are in use, and as yet no determination as to the best method seems to have been reached."

This uncertainty was emphasized by Reckenzaun's interesting paper at the opening session in the following fall, in which he discussed at length the various motor connecting possibilities, and recorded his surprise at the success of the direct single-gear reduction which was being used on a car equipped for Mr. Wharton of Philadelphia, where we were using a storage battery.

Supplanting those experiments, and others in New York and Boston, there had been a renewal of my interest in the larger problems of electric railways; this immediately centered upon equipment of the New York Elevated, where Daft was carrying on some experiments with a locomotive. The Edison-Field interests had combined, and they had assembled a number of dynamos to provide a 600-volt supply to a third rail on the 34th Street branch of the elevated, on which Stephen Field made a short-lived experiment with an electric locomotive governed by a water rheostat. I had developed what later became universal practice—the 3-point "wheelbarrow" geared suspension—by which the motor was centered on the driving axle at 2 points, so as to maintain parallelism between the armature

shaft and the axle, and was flexibly suspended at the free end to permit free movement. The Field experiments having terminated, Johnson arranged for of the same battery of dynamos to carry out an experiment for which motors, truck, and control apparatus were being prepared. Following a general description of the project made before the Society of Arts in Boston, December 1885, the first demonstration was made on a short track installed between the walls of the Durant Sugar Refinery at East 25th Street, New York City. With only a 150-ft run quick control was essential, with the result that while operating the car for Mr. Jay Gould, one of the owners of the Elevated, an overloaded safety strip blew up in a volcano and ended his interest in electrification.



Cross section of truck used in Durant Sugar Refinery test during winter of 1885–86, and from May to December 1896 on the 34th Street branch of the New York Elevated

"Wheelbarrow" 3-point suspension of single-reduction adjustably-geared motors is used, the universally adopted system on most trolley cars and on many locomotives

The success of the test, however, was such that one day Superintendent Chinnock of the Edison Company offered $30,000 for a $^1/_6$ interest, which being refused led him to express the opinion that I was a damn fool, because if successful the remaining interest would be sufficient to insure ample reward, and if not $30,000 was not to be disdained by any inventor.

While preparation for tests on the Elevated proceeded I went to Richmond, Va., for a short rest, but was surprised one Friday afternoon by a wire from Johnson saying that he had promised Cyrus Field to operate a car on the elevated tracks on the following Tuesday. Considering the state of the work my reaction to Johnson's optimism was not flattering; but I hastened back, and despite a strike at the Bergmann shops, where the controller was being built, and with all night work by candlelight, the equipment was assembled in time to present an air of respectability to a gathering of financiers and railway officials on the day appointed. Not a single test had been possible; and considering that it was proposed to handle by distant mechanical means from each end of the car single-brush high-powered motors at 600 volts, with both shunt field and rheostatic control, to regenerate power in slowing down to return energy to the line, and also to use the motor armatures as a final brake, one may imagine the mental attitude with which I faced the gathered throng. Even then I had to wait half an hour to get current on the line.

As arrangements had been made so that either motor could be cut out of circuit, first one was tried and then the other, but without movement. Finally, in sheer desperation both motors were connected, and there followed a perfect series of runs which demonstrated the soundness of the principles employed. Even now I wonder how we escaped complete failure, with burning up of the car and the wooden-cased controller and its German silver resistances. Following the departure of the guests, and while sitting on a tool box resting from the nervous reaction Chinnook offered $25,000 for a $^1/_{12}$ interest, which finally was accepted. As he was not a man of means I asked for whom the purchase had been made, and was told that it was for the president of the Edison Company, who had acted on spiritualistic advice! Later, a like interest was sold on joint account for $26,250, and subsequently the capital structure of what had been a private company was raised to a million dollars, with outside investors interested.

This equipment was notable in that the 3-point "wheelbarrow" motors were carried on an independent truck, below the car springs, ran with fixed position of tilting brushes for both directions of movement, and had field and rheostatic control of speed, regeneration and braking, as well as the interpole principle of winding for automatic maintenance of fixed brush nonsparking points regardless of load or direction of movement.

Tests continued until December of 1886, but without any special interest on the part of the railroad; and then on the suggestion of an associate I began the building of a 300-hp motor car, to be used as a smoker and to pull trailers. Each truck was to carry a pair of 75-hp duplex motors, adjustably geared to the axles, and with the field magnetic flux carried through the armatures in series, as was later done on the Bachelder locomotives for the New York Central Railroad.

About this time the entrance of Westinghouse into the lighting field with the alternating-current system, reinforced by Stanley's demonstration at Great Barrington and later by Tesla's polyphase motor, had aroused a bitter controversy with Edison, to whom the new system was anathema; and in 1886 I was requested by Johnson to report privately upon the subject. This report urged that the Edison interests, as a supplement to their own system, should actively take up a like development on the ground of economy in long distance transmission; but this recommendation was ignored, and in 1887 the alternating-current system was condemned in the famous "Red Book" as having no value except for lethal purposes.

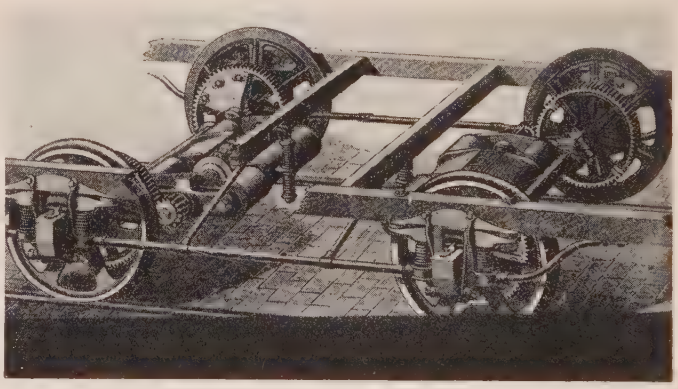
Finding that headway on the Elevated with any plan was improbable, attention was turned to the

problem of street car operation, in which field a number of pioneers, Van Depoele, Daft, Bentley, Knight, Henry, and others abroad, were actively experimenting or had made limited installations along varied lines. Supplementing an installation with one of the elevated motors at the East Boston Sugar Refinery, individual cars with Julian storage batteries were operated in Philadelphia, New York, and Boston, and then suddenly the opportunity arose to take contracts in the spring of 1887 for equipment of, among others, the Union Passenger Railways in St. Joseph, Mo., and Richmond, Va. At this time, according to Mr. Martin's summary published in the 1887 volume of the A.I.E.E. TRANSACTIONS (p. 183–7) there were about a dozen and a half installations in Europe and the United States, including every conceivable kind of equipment, totalling about 112 cars and locomotives, concerning which I already have quoted his conclusions. He was not, of course, aware of my early suggested plans for equipment of the London underground railways; and the experiments at the Durant Sugar Refinery and on the 34th Street branch of the New York Elevated were of private character.

The Richmond Road

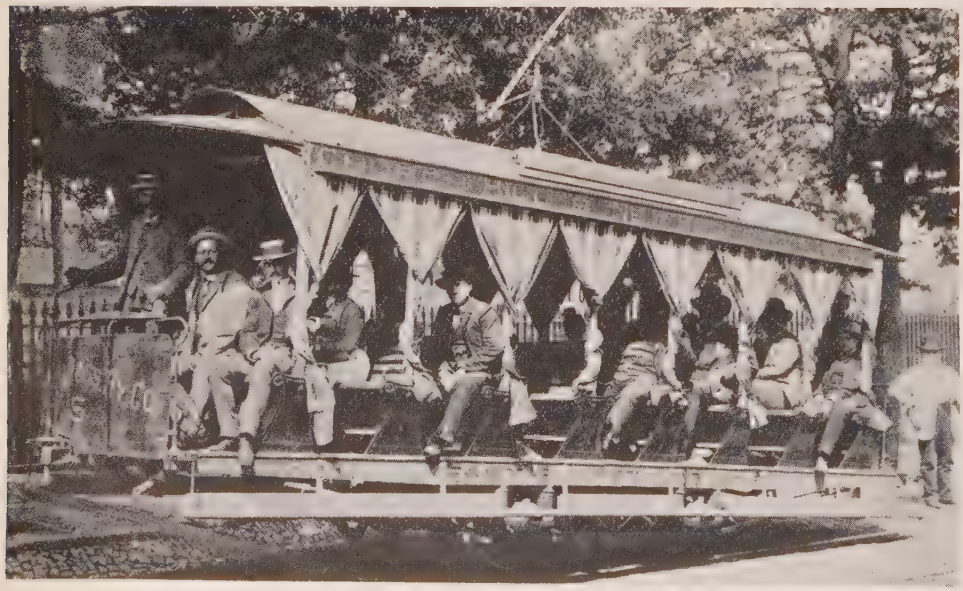
The story of this pioneering enterprise, undertaken under extreme conditions and in the face of general predictions of failure, was reviewed at the Kansas City Convention of the National Electric Association in 1890; it has been told so often that only limited reference need be made to it here. Briefly stated, it called for the equipment of 40 cars with 80 motors, more than the aggregate of either European or American established installations, and supplemented by the St. Joseph contract exceeded the total. They were to be operated on an unlaid railroad presenting a combination of curves and grades of unusually difficult character, and the contract included a complete central station. The installation was to be completed in 90 days, with payment of $110,000 "if satisfactory." Our working plans were based on a rough blueprint of a motor and the records of our experimental work. Shortly after the contract was made I was stricken with typhoid fever, and while convalescing took a western trip, leaving the work at St. Joseph in the hands of David Mason, and at Richmond and the New York Shops to Lt. Oscar Crosby and Ensign Dana Greene. On my return in August initial runs were made at St. Joseph, but up to that time I had not been to Richmond; and it was not until the actual conditions there were seen that the critical situation which faced us was realized, one opinion being later summarized during operation in a message to Greene—"This is hell!" With a hard working crew and constant shuttling between Richmond and New York, continued public operation began Feb. 3, 1888, but with an immediate succession of heartbreaking difficulties which, finally overcome, enabled 30 cars, later increased to 40, to be put in operation on May 4, designated by the American Electric Railway Association as National Electric Railway Day.

Among the principal features was a main and working conductor system, with feeders supplied at 450 to 500 volts, paralel-circuit supply, centrally located universal swiveling undercontact trolley, "wheelbarrow" suspension of geared motors, with adjustable double drive and single gear reduction (later changed to double reduction) duplicate double-ended series-paralel control, fixed metal brushes (later replaced by Van Depoele's carbon)



(Above) A trolley car truck equipped with "No. 5 type" 7½-hp motors built in 1887 and used on early Sprague roads in St. Joseph (Mo.), Richmond (Va.) and elsewhere

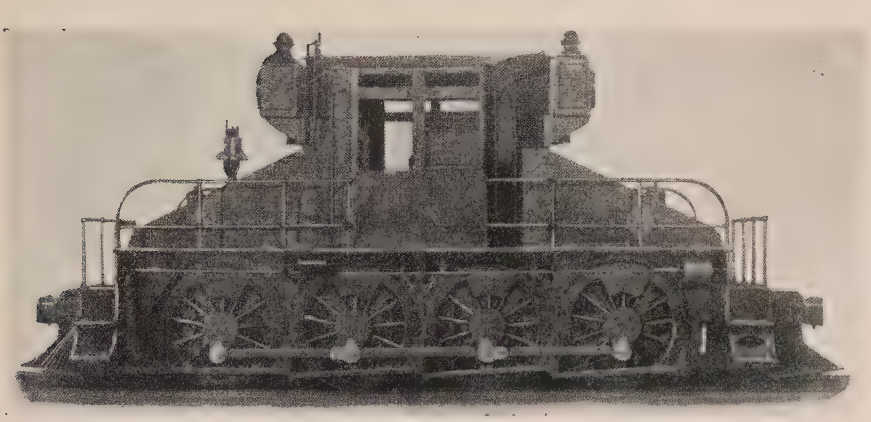
Double-end single reduction gear drive; adjustable gear at one end; 3-point "wheelbarrow" suspension; fixed brushes; double commutator; sectionalized field windings; series-parallel control. Double reduction gearing soon followed, and then the 15-hp "No. 6" motor



(Left) An early Richmond (Va.) trolley car (1888) illustrating one of the first applications of the universal trolley

Assembly of 22 trolley cars (1888) at the terminal of the Richmond road

These show the centrally located universally swiveled undercontact trolley. The mass starting of this group was one of the factors that determined the abandonment of the projected cable system in Boston, Mass., and the adoption of electricity



A 1,000-hp 60-ton electric locomotive built in 1892–93 after designs by Sprague, Duncan, and Hutchinson, the first heavy duty electric locomotive ever built

The motor armatures were mounted on the axles, and the fields on axle boxes. This locomotive included the first railway application of a pilot controller—the main controller was too big for a man to operate

and lightning arresters. In the very month of the 30-car operation, requiring an average of about 200 hp, prediction was publicly made that 20 cars would require 2,250 hp, and that it would be impossible to operate 30 cars. Later the series method was promoted for use in England, with many high professional endorsements of its possibilities, and the inevitable outcome was referred to as "The Debacle of the Four Professors."

Doctor Holmes' happy references to the trolley in "Over the Teacup" and in his poem on "The Broomstick Train, or the Return of the Witches" are eloquent recognition of the new development. The confidence following the surprise of the native population in Richmond at seeing the heavy grades conquered by an unseen power was later voiced in a circular calling a mass meeting to demand the electrification of a road in New Orleans, La., which was headed: "Lincoln set the slaves free! Sprague has set the mule free! The long haired mule shall no longer adorn our streets."

The Richmond success, although attended by a loss of fully $75,000 dollars, was emphasized in 2 years by Sprague contracts for at least 110 railroads, including the first foreign trolley roads at Florence, Italy, and Halle, Germany, with replacement of several of the experimental equipments in the United States, and marked one of the most remarkable of industrial developments. Meanwhile the Thomson-Houston Company, which had purchased the Van Depoele interests after I declined them, had actively entered the field, and in 1890 was followed by the Westinghouse company. Among the most notable Sprague contracts were the initial one of the West End Railroad at Boston, determined after a critical mass movement demonstration at Richmond for President Whitney, and that for the abolition of cable operation at Minneapolis and St. Paul.

The Institute had meanwhile enlarged its record of Transactions, and in catholic fashion continued full records of professional papers presented, so that one on "The Solution of Municipal Rapid Transit," read at the Columbia University meeting, June 19, 1888, was published in full, it and the discussion taking no less than 84 pages. By August 1, 1890, at which time reappeared the impractical suggestion of using 2 rails alone as conductors at 20 volts supplied by motor-generators, 412 companies in the United States alone, over 40 per cent of the total, had adopted the overhead contact electric railway system for the operation of 6,732 cars on 3,000 miles of track.

Telephone Troubles

The Richmond installation promptly precipitated legal contests with telephone companies in a score or more of states because of inductive interferences, and particularly cross leakage on the common ground circuits. An early decision against the single trolley with ground return was made by Judge, later President, Taft in the Superior Court at Cincinnati; but this was reversed by the Supreme Court, and thereafter the railroads were entitled to the common heritage. The final result was of the greatest benefit to the telephone industry, because it forced the use of complete balanced metallic circuits, without

which long distance, or even extended successful local, telephony would be impracticable.

A New Deal

The Richmond installation now is acknowledged as the prototype of the modern trolley and the beginning of commercial electric traction. Awake to the new possibilities, the Edison General Electric Company invested $400,000 in the Sprague company, and in 1889 decided to acquire control of it. In the annual report for that year it was stated that of the 200 electric railways that had been generally contracted for, over 90 per cent were built under Sprague patents and that the company had 3,000 motors of all kinds in operation.

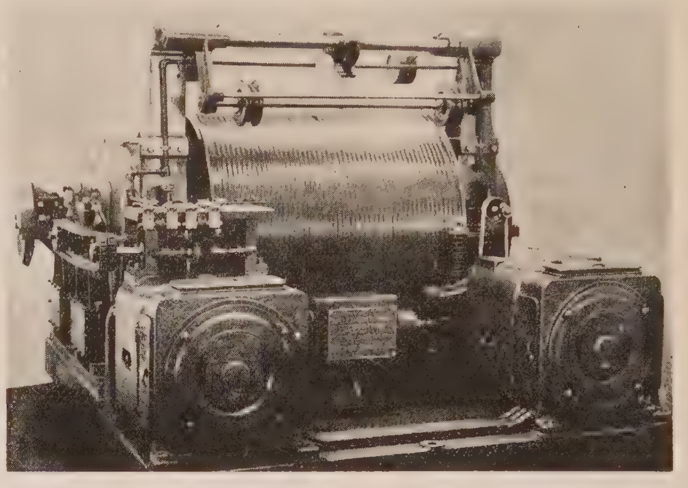
On the consolidation I consented to remain awhile as consulting engineer, but soon found existence of a policy that threatened trolley development and proposed the impossible low potential rail substitute for city operation; realizing this my resignation was tendered in unmistakable terms. It was not until long afterward, however, that there came into my possession an interoffice copy of instructions which announced that, following the purchase of the Sprague company, the system I had developed was to be designated by another name, an act the injustice of which largely has been rectified by time's perspective.

Underground Rapid Transit

The intense activity in the street car electrification naturally had 2 reactions, one the hasty and unwarranted prophecies of the replacement of steam for main line operation, and the other of more immediate importance, its bearing upon the much talked of project for expansion of rapid transit facilities in New York City—to be developed under a newly created board of estimate. Free from immediate commercial responsibilities I turned to this problem with the keenest interest, and having become one of the representatives of the Greathead Shield system of tunneling, in the early part of 1891 I outlined a deep level system at the Electric Club, following this by a comprehensive plan in the *Commercial Advertiser*.

At the May meeting of the Institute I outlined the considerations that should govern the decision with regard to a rapid transit system, citing 3 main features that should be determined in the order indicated, namely, motive power, method of construction, and routes, emphasizing the vital necessity of adopting electric equipment so that there would remain a free choice regarding the other features. Later, in opposition to the Manhattan Elevated Railroad Company's plan to extend its obsolescing system up Broadway, I made (June 13, 1891) a public proposal to install on the Second Avenue line, at a personal risk of $50,000, 2 6-car trains, one to be operated by a locomotive and the other by motors under the cars, at a speed of 40 mph. In my communication to the board of estimate I had stated that if electricity was adopted I was willing to undertake contract for both the steam and electrical equipment for not less than 50 way and express trains. These various manoeuvres were instrumental in preventing any extension of the elevated structure, and compelled serious study of the possibilities of electrical operation.

In my inaugural address as President of the Institute in the following year, on the subject of "Coming Development of Electric Railways," I took occasion to review what had been accomplished in electric traction, and to warn against undue optimism and unwarranted predictions with regard to the prophesied early demise of the steam locomotive.



One of the 49 100- to 150-hp duplex-drive elevator machines built for the Central London Railway, 1897–98

This was by far the largest elevator contract, hydraulic or electric, awarded to that date, and its successful operation was a powerful influence in emphasizing the supremacy of the electric system

New Departure

Following the acquisition of the Sprague company, the late Dr. Louis Duncan, Dr. Cary Hutchinson, and myself became associated, designing and building in 1892–93 for Mr. Henry Villard of the North American Company the first large electric locomotive—one of 60 tons and 1,000 hp, with 4 coupled axles, each to be driven by motors whose armatures were mounted on the axles and the field magnets carried on the axle boxes, with an air-operated main controller actuated by a follow-up master one. Intended for experiments near Chicago, financial reverses ended this scheme; and, after testing, the locomotive, the motors for which were built by the Westinghouse company, was laid up at the Watsessing Works of the Sprague Electric Company and finally dismantled, an unfortunate destruction of a historical machine.

Establishing a private laboratory on West 23d Street, New York City, one of the first experiments undertaken was the construction of an a-c induction furnace, in which the contained metal formed a part of the single turn secondary of a transformer. While

successful theoretically and experimentally, the limited a-c supply available led to abandonment of the work, and with Charles Pratt I took up the development of a screw-driven multiple-sheave electric elevator, essaying through the Sprague Electric Elevator Company the modest task of displacement of the well-established hydraulic system.

Following the erection of one machine at the laboratory, another was installed in the Grand Hotel at 33d Street and Broadway, New York City, and later the idea was sold to George Harding, architect for a building to be erected for the Postal Telegraph Co. at Broadway at Murray St. Here in 1893–94 was installed (and later described in the TRANSACTIONS) the first battery of electric elevators—high speed passenger ones—under a guarantee that if not satisfactory they would be replaced by any selected hydraulic type. The development of this equipment was not without grief, and on one occasion jeopardy to life of practically my entire crew and myself while operating the first car without proper current limit and car safeties.

The entrance of the Sprague company into the field of vertical traction, of course, faced the combined opposition of the established hydraulic companies and the natural conservatism of architects, builders, and owners; but progress was steady and included many types, among those the pushbutton automatic elevator controlled from floor and car, which was the forerunner of the modern signal-controlled elevators.

Multiple-Unit System of Train Control

The Postal Telegraph building elevator equipment had been notable not only for distant pilot control, with the dead man's switch and the flexible

One of the first practical tests of multiple-unit control, and forerunner of the universal multiple-unit system of train control

Test made during the summer of 1896 at the Sprague shop, Watsessing, N. J., on 4 sidewalk elevator machines equipped with individual controllers, train line, relays, throttle, and master controller, and one with only the "train line"

iron grid rheostats now universally used on heavy work, but also for a testing arrangement which was the forerunner of the invention of the multiple-unit system of electric railway operation. Provision was made such that in addition to individual car control any elevator could be operated from another controller located in the basement. One day, from sheer curiosity, all main pilot controllers were connected in and operated by the "master," with erratic results that for a time quickly ended experiments.

In 1895, my interest in the railway problem being renewed, one day it flashed across my mind that by using the principle demonstrated by the experiment with the Postal elevators I could equip cars individually with power-operated controllers, and combine them into trains of any desired length, regardless of sequence or end relation, and control them from any point by master controllers through an independent jointed train line. No sooner had this idea germinated than it was completely described, with particular reference to use on the elevated railway, preliminary tests were made with a group of sidewalk elevator machines, and 2 offers were made to the elevated railway management to install 6- and 8-car test trains at my own expense, but without any response whatever.

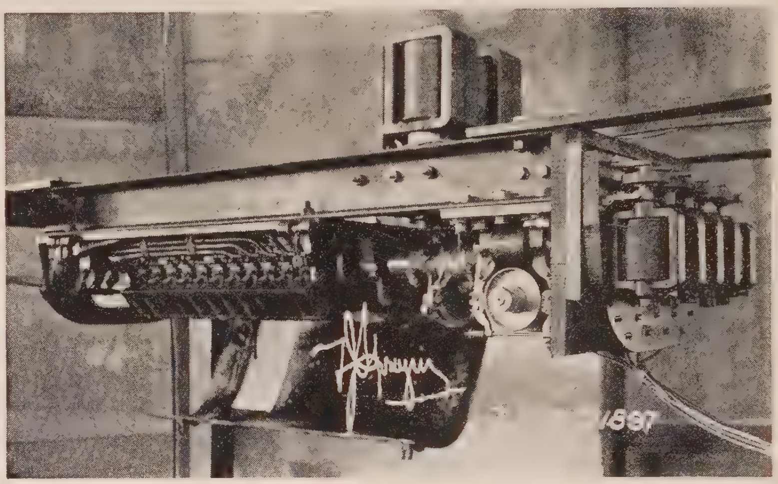
In 1897, however, one of my most difficult years, opportunity arose to put the system into practice. While recovering from a serious fall when installing elevators at the Waldorf Hotel, New York, a trip to London was suggested to seek an elevator contract for the new railway under construction from the Bank to Shepard's Bush. On receipt of specifications, plans rapidly were developed; but shortly before time for sailing a request came inviting me to act as consulting engineer for the South Side Elevated of Chicago, a steam operated road then in the hands of a receiver. Still on crutches and burdened with the work in hand, a new responsibility was unwelcome; but there soon arrived an old friend, Fred Sargent of the firm of Sargent and Lundy, who brought their specifications and a new proposal, and I was asked to make a report, with special reference to their steam plans. Agreeing to give 2 days to its consideration, I saw that 3 companies had made proposals for motor-car and trailer operations, and instantly I saw my opportunity. This was emphasized by the complexity of conclusions that a few weeks before had been presented by John Findlay Wallace, at the February 3, 1897, meeting of the American Society of Civil Engineers, covering several years' study of the "Substitution of Steam as a Motor for Suburban Traffic." Explaining the possibilities of multiple-unit equipment and operation, I won the interest of Sargent, as well as that of William J. Clark, the commercial railway engineer of the General Electric Company, and later of his assistant Frank Shepard.

Delaying sailing, I made a report in a week endorsing the air condenser steam system, about which Sargent knew much more than I did, but condemning the proposed electrical equipment and offering personally to contract for an equipment of the road on the new system. The opposition that developed was of no mean proportion, but although not then in the railroad business, and refusing to give any guarantee other than my own technical experience and a prediction that the bidding companies would seek orders from me for motors, I soon won out. Having to sail for London I left the signing of a contract for nearly $300,000, drawn up with special care by the engineers and officers of the railroad after

First full-train test of 6 cars operated with the Sprague multiple-unit system at Schenectady, N. Y., on July 26, 1897. These were the first section of the 120-car installation on the South Side Elevated of Chicago

(Below) First of the multiple-unit controllers to be used in the 1897 tests at Schenectady

This shows a series-parallel standard controller driven by a pilot motor, the reverser, throttle, and relay, but not the train line and master controller



my departure, to a young assistant, C. W. McKay, with the handicap of a $100,000 penal bond. This contract called for the equipment of 120 cars with 240 motors, and a 6-car train was to be put into operation by July 15 on a system that existed chiefly in type. I had taken the contract personally, and it was not until my return that arrangements were made to have it taken over by a new company, the Sprague Electric, a combination of the Sprague Electric Elevator and the Interior Conduit and Insulating Companies, the largest stockholder being John W. Mackay.

Meanwhile, to get approval of conservative English engineers and financiers for the largest elevator equipment of any character undertaken up to that time, and an electrical one, on which the success of the underground railroad depended, was a technical and financial problem that taxed the resources of diplomacy; but electricity won, and a contract for nearly half a million dollars was secured on the condition that while the entire work would be proceeded with, we would stand or fall, without recourse, on a test under the direction of the road's engineers, the principal of whom was the late Sir Benjamin Baker, of an advance installation to be made in one of their shafts, which varied from 18 to 30 ft in diameter. I returned to the United States the latter part of June, with the multiple-unit system still on paper except for such preliminary work as could be directed by cable, and with only 3 weeks to prepare for crucial tests. Despite a general strike at our Watsessing shops 2 cars were run on the 16th day of July, and by the 25th, my birthday, a train of 6 cars was ready for demonstration on the tracks of the General Electric Company at Schenectady, N. Y., under an agreement that permitted rejection on adverse decision by either an engineer or officer of the road. The test succeeded, however, and I was able the next day to telegraph to Miss Sarah Farmer, at whose home in Maine the A.I.E.E. was holding its annual convention, word of the success of the new departure on the fiftieth anniversary of her father's experiments at Dover, N. H.

The equipment was progressed rapidly, and by the following spring all steam locomotives were displaced. This project had likewise to go through its birth pains, with heavy losses, but the system installed 37 years ago is still in operation, the multiple-unit system has never been changed in principle or essentials, and it is now universally used where 2 or more motor-equipped units, whether on elevateds or subways, suburban trains or main line locomotive operation, are under a common control.

A happily facetious letter from B. E. Sunny on a recent birthday is typical of the almost universal doubt and ridicule with which the new system was greeted, and warrants an excerpt.

" 'He invented the multiple-unit system and applied it to the South Side Elevated in 1898' and thereby hangs a tale.

"I was manager of the General Electric Company in Chicago at that time, and we had had the business of the Elevated Railroad in motors, etc., for some years, and a contract for equipment had been negotiated which contemplated an addition to the old method, the only one known, of a heavily serviced motor car capable of pulling a number of trailers.

"I called on Mr. Hopkins, the general manager, one morning, expecting to receive the signed contract, but found him in rather bad humor. One of the directors had met a fellow in New York with a military title, who had put in an electrically appointed dumb waiter for delivering cocktails to the several floors in a big hotel, which worked perfectly, and he proposed to apply the same scheme to the operation of elevated trains. This seemed to us to be just too funny for anything and we both had a good laugh over it.

"Mr. Hopkins telephoned me the next day that the name of the magician was Lieutenant Frank Sprague, and then it wasn't so funny. Your fame in electric railways was widespread, and you were a terrible man to meet in competition. I saw that fine contract in those days of bad business following the '94 panic slipping away, and it made me feel pretty bad.

"Then you came to Chicago, and the story was that you had no shop; no organization; no installers—just a tooth brush and an idea, but Ye Gods, what an idea! Most men with an idea like that would not have had the presence of mind to carry even a tooth-brush

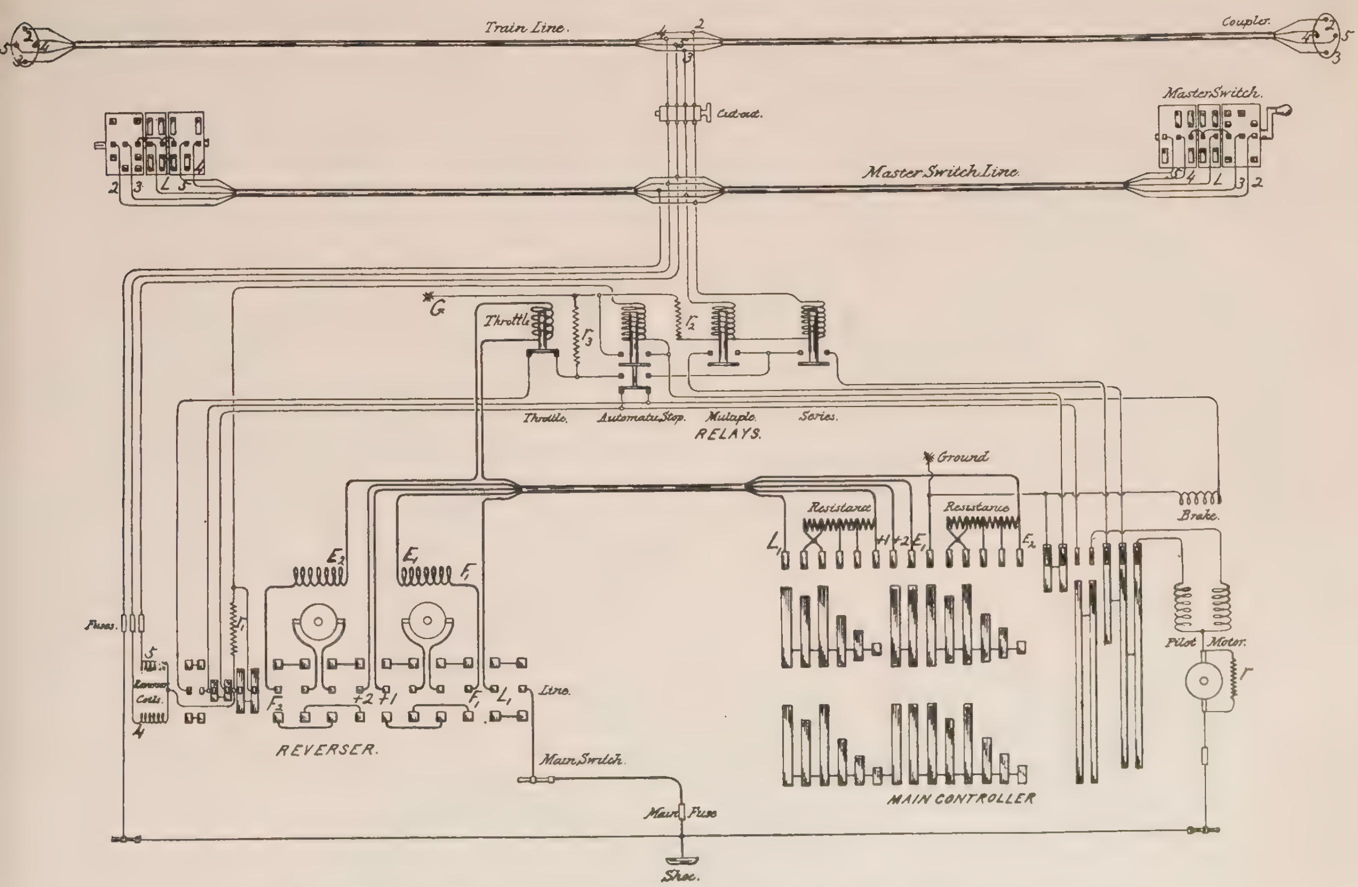
additional! We lost the contract; you won, and it was a great day for railway transportation, for the application of your multiple-control system has been the greatest boon that has come to that most important public service. Indeed, the wonderful results could not have been secured in any other way."

A full description of this equipment appeared in the 1899 volume of the TRANSACTIONS. The success of the system and the commercial undertakings of the large manufacturing companies soon made it essential that control of the Sprague company should be secured, since it was unlikely that a fundamental patent with 246 claims could be broken. This was done in 1902 through the General Electric Company for itself and the Westinghouse and the British Thomson-Houston companies, and after the equipment of a section of one of the French railways, also by the French Thomson-Houston Company, under agreements that by whomsoever used the system should at least carry the Sprague designation, a condition which only partly has been lived up to. The inception of the system and its world-wide adoption and use, however, were emphasized by the unique and gracious testimonial tendered me in recognition of my 75th birthday 27 years after the Institute, at its annual dinner on February 8, 1905, celebrated "The Triumph of Electric Traction."

Before the consolidations referred to were effected, after a million-dollar successful fight to effect the obsolescence of the hydraulic elevator and the supremacy of the electric, which included the building of 584 machines for the equipment of the largest buildings and the Central London Railway, a combination of elevator companies was effected and this part of our business was sold to it. The traction type originally was proposed for a projected memorial to George Morison, to be erected in Chicago, and in 1906 developed by me with use of the equalizing sheave characteristic of street cable systems. It was introduced into commercial practice by the Otis company about the same time.

ELECTRIFICATION OF THE NEW YORK CENTRAL TERMINAL

A grave accident on the New York Central Railroad led to the passing of a law requiring the abandonment of steam as a motive power in the terminal tunnels, and I offered to demonstrate within a year the hauling of a regular train by an electric locomotive. Instead, a Committee for Electrification was formed in 1902, under Vice-President Wilgus, the other members being Superintendent of Motive Power Waite, B. J. Arnold, George Gibbs, and myself. Deciding to extend the equipment beyond the legal requirements, plans promptly were detailed and completed. Final decision was for 600-volt d-c equipment, current being taken from a protected undercontact third rail supplied from substation



Typical circuits of the Sprague multiple-unit system for both car and train assembly

This is an 1897 working diagram and shows the fundamental circuits from which evolved the entire multiple-unit system. A peculiarity of the train line and jumper connections is the arrangement of the speed controlling wires so that they always coupled alike, while the reversing wires are changed on the reversal of cars in train assembly. This was to assure proper direction of train movement relative to truck movement with like movement of the master controller handle in any combination—a fundamental condition for universal assembly

rotary converters, to the transformers of which 3-phase alternating current at 25 cycles was transmitted from 2 main stations equipped with vertical turbines. Gearless locomotives of the Bachelder type were adopted, together with multiple-unit control for them and the suburban cars. In spite of the pressure to adopt other methods, and regardless of the advances that have been made since, no other choice was then practicable, and the performance of the whole equipment, which was initiated in 1905, has fully justified the commission's decision. This was followed a year later by a very extended paper in the A.I.E.E. TRANSACTIONS on trunk line operation.

THE A-C–D-C CONTROVERSY

The adoption of single-phase equipments on some suburban railways, mostly later abandoned for 1,200-volt d-c operation, and on the first section of the New Haven road, was cause for temperamental explosions as to the merits of the different systems, many claims without warrant being vociferously advanced. In this caldron of controversy I found myself deeply involved, sometimes even being charged as the champion of exclusive d-c operation. This was far from the fact, as various papers, discussions and the Institute's records fully demonstrate; but I did offer to assume the responsibility, and urged the advisability, of raising the limits of potential in d-c operation, and without hesitation pointed out the weaknesses of many claims made, stating that a fair comparison of systems was possible only when each was developed to its limit. Twenty years ago I proposed the organization of a commission, which would include the highest technical authorities, to seek in coöperation with the manufacturing companies and railroads a common conclusion a proposal the wisdom of which has lately been amply vindicated. With regard to potentials I had stated in 1890 before the National Electric Light Association that whatever was necessary would be used without fear of results; perfectly successful operation with even d-c equipment is now conducted at the potentials then indicated.

AUXILIARY TRAIN CONTROL

With the electrification of the New York Central completed, ambition turned to the need of making railway operation in general safer by automatically forcing obedience to wayside signals without undue interference with the proper control of the train by the engineer. After a long development on the General Electric tracks at Schenectady, followed by supporting reports, the Sprague Safety Control and Signal Corporation was formed; critical tests of an intermittent inductive system, with speed control, were undertaken on the New York Central Railroad, under exacting limitations determined jointly by representatives of the Interstate Commerce Commission and a committee of the railroads, which I agreed to meet—and then some. On the declaration of the World War this work was partly suspended, and on the formation of the U.S. Naval Consulting Board, in the details of which I was active, the Institute was 1 of 11 societies requested to nominate members, Mr. Lamme and I representing it. Although acting as chairman of the committee on electricity and shipbuilding, my principal activities were in the development of depth charges and delay-action fuses for armor-piercing shells.

Acting under authority of Congress, the Interstate Commerce Commission in 1924 issued orders requiring 49 railroads each to equip a full division with train control, supplementing this by another order 2 years later—all, however, with an unfortunate latitude of construction and requirements. For many reasons I had anticipated that the successful conclusion of the original New York Central tests and a later section trial would be followed by a division installation; but failing this, action was transferred to a number of western railroad divisions, where I agreed to meet any requirements of the commission. There followed a period of successful operation, and then commercial collapse due in part to a change of policy by the Commission and the troubles incident to railroad financing and operation in the recent depression. The period of activity in this field, extending from about 1911 to 1933, was one of great trial and strain, and, considering the commercial results, might have been more advantageously spent in some other direction.

DUPLEX ELEVATORS

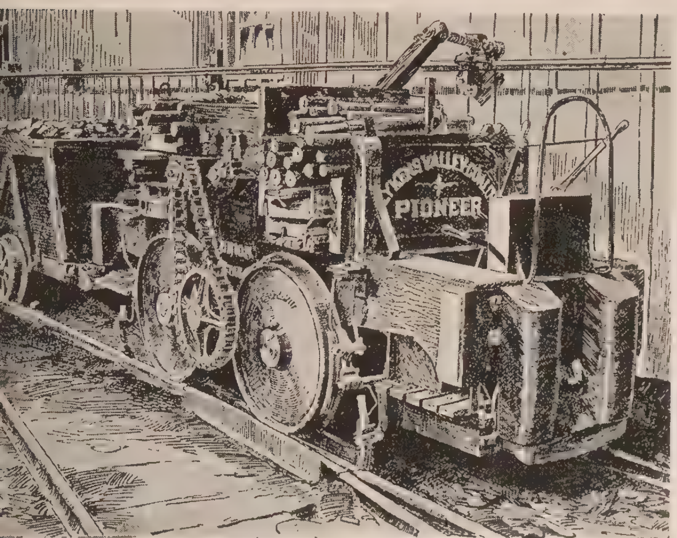
During the latter part of this period vertical transportation again attracted my attention, with the sudden development of a method for safely and freely operating, within proper limits, 2 independent elevators on common rails in a single shaft, to conserve valuable floor space. The upper elevator normally was to be operated on express service and the lower on a shorter local run, 2 lower floor landings being provided. Every elevator has 2 limits, upper and lower, for which automatic operation must be provided. To operate 2 elevators as proposed in 1 shaft it was necessary to provide a floating lower limit for the upper car and a similar floating upper limit for the lower one, these being jointly controlled and actuated through differential action of the main controllers. The first working model was built within a fortnight after conception, and the system, together with a method for actuating the car safeties by excess of acceleration as well as excess speed, was sold to the Westinghouse company. This transaction was attended by a coincidence of remarkable character, the passing of a check in part payment by Vice-President Charles Terry, of exactly the same amount given me by his brother, Professor Terry of Annapolis, over 2 score years earlier.

And now, after many years in which the Institute has signally honored me, still at work in a new development in the difficult days of a new deal, or ideal—and hoping! The 3 score years have been those of a ready acceptance of any challenge in electrical engineering progress, a mental elixir which has made life worth living in the effort to add to human progress and comfort, the zest for which advancing years has not entirely abated.

A Few High Lights in Electrical Transportation

(Above) Electric locomotive built by Moses G. Farmer in 1847, now in the Smithsonian Institute, Washington, D. C. Mr. Farmer used the apparatus when lecturing on electricity
(General Electric photo)

(Below) An electric carriage built in 1893, which weighed 5,100 lb and was capable of attaining a speed of 16 mph
(Holtzer-Cabot photo)



(Above) An electric mine locomotive built about 1888 for the Lykens Valley (Pa.) Coal Company
(General Electric photo)

The achievements in horizontal transportation have been paralleled by equally striking achievements in vertical transportation. At the right is shown one of the elevators recently installed at the Rockefeller Center in New York City; these are the fastest elevators ever built, being capable of a speed of 1,200 ft per minute. The doors of all cars are protected by photoelectric equipment so arranged that an obstruction in the doorway will prevent the door from closing
(Westinghouse photo)

(Above) First electric locomotive built for the Baltimore and Ohio "Belt Line," 1895. The locomotive weighed 96 tons and was equipped with 4 6-pole gearless motors of 360 hp each
(General Electric photo)

(Left) One of the latest 90-mph a-c locomotives built for the Pennsylvania Railroad in 1932–33; it weighs 190 tons and is powered by 3 twin motors with a total continuous rating of 3,750 hp
(General Electric photo)

Alternating Current Versus Direct Current

By Lewis B. Stillwell, President A.I.E.E. 1909–10

An episode of early commercial competition within the electrical industry by a past-president of the Institute who was an "eye witness" to the controversy.

THE preëminent American leader in the development and commercial introduction of the alternating-current system of transmitting and distributing electricity for lighting and power purposes was George Westinghouse of Pittsburgh, Pa., the inventor of the air brake. In 1885 the Gaulard and Gibbs lighting system, invented by the brilliant Frenchman Gaulard, was exhibited at Turin and at the Inventions Exhibition in London. The apparatus employed was crude, but it included the transformer, the key to the problem of electrical transmission.

Mr. Westinghouse promptly secured control of the American patents of Gaulard and Gibbs, incorporated the Westinghouse Electric Company, and began to build up a staff. Before the end of 1886, several central station lighting plants had been sold and the company was in active competition with the Edison Electric Light Company, which for several years had been practically in sole control of the American field of electric lighting by incandescent lamps supplied from central stations.

Edison's brilliant invention of a commercial incandescent lamp had been followed promptly by his feeder and main patent, and by his 3-wire system of distribution. His first central station in Goerck Street, New York City, was a convincing demonstration of the commercial possibilities of the new lighting system, and the pioneer installation in New York had been followed with remarkable promptness by similar plants in a number of other American cities. Adequate financial support had been secured; the Edison Electric Light Company had been organized to manufacture incandescent lamps, central station and distributing apparatus and, in short everything necessary from dynamos to lamps inclusive. Not only had Edison's work been brilliant, but also it had been extraordinarily direct and practical. When Westinghouse acquired the American rights of Gaulard and Gibbs, the Edison Manufacturing Company was a going concern; its activities were extending rapidly and a great commercial success seemed assured.

During the year 1887 a number of alternating-current central lighting stations were installed by the Westinghouse Company in various American cities. The reaction of the Edison Manufacturing Company was prompt and vigorous. The usual methods of commercial competition having failed to stop the invader, unusual defensive measures were adopted.

A bill was introduced in the Senate of the State of Virginia prohibiting the use in that state of any electrical potential exceeding 800 volts; and a committee of 15 Senators was appointed to hold public hearings and report to the Senate.

Howard Levis, Esq., at that time one of the Westinghouse Electric Company's counsel, was instructed to oppose the bill, and I was detailed to coöperate with him.

Learning that Mr. Edison himself was to appear before the committee, President Morton of Stevens Institute of Technology, an eminent authority on engineering matters, was retained for the Westinghouse company, as also was Captain Hugh Garden, counsel of the Sawyer-Mann Electric Company, which had been acquired by Westinghouse interests. Wyndham R. Meredith, Esq., a brilliant young lawyer of Richmond, Va., also was retained.

The day of the hearing arrived. Many residents of Richmond were interested to see and hear Mr. Edison, and the first meeting of the committee was held in the historic hall of the House of Delegates at the capitol. The hall was well filled by a representative gathering of legislators, other public officials, and representative citizens of Richmond, including many ladies.

After the usual formalities, and a statement by the chairman of the committee, Mr. Meredith arose. He began by extending to Mr. Edison a warm welcome to Virginia and in eloquent and most courteous words thanked him for his visit to Richmond. He recalled the fact that "Franklin often had left the laboratories of science for the halls of legislation," and in doing this invariably had been actuated by his deep interest in the public welfare. Mr. Meredith expressed the hope and his personal confidence that in honoring Virginia with a visit, Mr. Edison was actuated by motives no less admirable. It would have been impossible to concentrate the thought of the audience on the question "Why does Mr. Edison come to Richmond?" in a manner more graceful and adroit.

Following the conclusion of Mr. Meredith's able address, which was greeted by the audience with hearty and continued applause, Mr. Edison was called as the first witness in support of the bill. He was questioned by counsel presumably retained by the Edison company and occasionally by members of the committee. His unfortunate deafness made it very difficult for him to hear the questions asked and it was necessary very frequently to repeat them, as a consequence of which his testimony was neither consecutive nor convincing. It was made clear, however, that he favored the bill, and it was evident

that the audience was much interested to see and hear him.

Following Mr. Edison, President Morton was introduced; he made an admirable address which lasted about 20 minutes. Dr. Morton had few, if any, superiors in describing technical matters in popular language, and on this occasion he put forth one of his best efforts. Among other things, Mr. Edison had said in effect that the continuous current was like a river flowing peacefully to the sea, while he compared the alternating current to a torrent rushing violently over a precipice. Dr. Morton courteously suggested that it would be more accurate to compare the continuous current to water flowing in one direction through a pipe, and the alternating current to water moving first in one direction and then in the opposite direction in the same pipe. It would have been difficult for any one in 20 minutes in nontechnical language to make a statement of the question at issue more reasonable and convincing than Dr. Morton's. While it is highly improbable that any large proportion of the audience, or even of the committee, understood what it was all about, the effect apparently was soothing; and when he finished the alternating current system seemed much less dangerous.

Senate Bill No. 238
Virginia Legislature, Session of 1889-1890.

A BILL

For the prevention of danger from electric currents.

Patron—Mr. Lovenstein.

Referred to the Committee on General Laws.

1. Be it enacted by the General Assembly of Virginia, That it shall be unlawful, on and after the first of April, one thousand eight hundred and ninety, to own, keep, or maintain, in, across, through, or under any public street, highway, or place to which the public commonly has access, any electric circuit, or part thereof, or any substance or thing for the conducting of electricity forming a part of an electric circuit, contrary to the provisions of this act.

In all electric circuits or parts of circuits as aforesaid, whether such circuits be in whole or in part under or above ground, the electric pressure used shall not exceed the following amounts: The non-pulsating continuous current to a pressure not exceeding eight hundred volts; the pulsating continuous current to a pressure not exceeding five hundred and fifty volts;

2

the alternating current to a pressure not exceeding two hundred volts, according to the nature of the current used.

After the passage of this act It shall not be lawful for any individual or corporation, public or private to generate or use, or cause to be used for distribution to the public, directly or by induction, any electric current with sufficient electric pressure to produce ~~death~~ human death accidentally by the direct action of such current,

Thomas A. Edison

The first page of the Virginia bill to limit electric potentials in that state to 800 volts (left above); a hand-written note regarding the bill by Mr. Edison (left); and portions of a newspaper account of the hearing from a contemporary paper (right)

THE BILL KILLED.

THE ELECTRIC TALKERS BEFORE THE SENATE COMMITTEE.

THE SPEECHES MADE TO-DAY.

The discussion of the Senate bill to regulate the use of electric currents throughout the State of Virginia attracted a very large number of people to the hall of the House of Delegates in the Capitol last night. Col. Boulware, representing the Edison Electric Light Company, advocated the passage of the bill, presenting Mr. Edison himself as recommending it.

In reply to inquiries Mr. Edison gave a short exposition of his views on the subject, and was followed by Mr. Harold P. Brown, of New York, popularly known as "the electrical executioner" from his connection with the various tests made in New York city to prove that electricity will kill.

Mr. W. R. Meredith, the attorney for the Electric Light and Power Company of this city, stated that the passage of the proposed bill would force his company to abandon its business, and introduced Prof. Morton, of the famous Stevens Institute of Technology, an

* * * *

The audience this morning was not as large as last night, the great attraction, Mr. Edison, not being present. Mr. Brown left for New York last night.

Professor Morton and Mr. R. W. Pope, secretary of the American Institute of Electrical Engineers, spent the afternoon with Mr. M. B. Leonard, the superintendent of telegraph of the Chesapeake and Ohio railway, in visiting the power stations of the Electric railway and the Electric Light and Power Company, which, it is stated, would be obliged to go out of business if this bill becomes a law.

RECOMMENDED THAT IT DO NOT PASS.

The Senate Committee on General Laws to-day reported Senate bill for the prevention of danger from electric currents, with a recommendation that it do not pass. The committee thought it was a mat or municipal authorities.

The committee then called Captain Garden to the stand. The Captain was a cultured and delightful southern gentleman of the best type. At the battle of Gettysburg he had commanded a South Carolina battery, and had left a large proportion of his men on the field. After the Civil War he had settled at Warrenton, Va. His testimony was given in an address which was followed with close interest by his audience. It was eloquent, if somewhat flowery, and he had not spoken long when I noted several of the Senators whispering to each other and looking at him intently. They were recognizing him as Captain Garden of Warrenton, and it was evident that they listened with sympathetic interest and with pride.

Before Captain Garden's testimony was concluded, Mr. Levis and I had learned that a number of representatives of companies operating electric arc lights in various towns in Virginia were present and desired to be heard. As they were using potentials up to 3,000 volts, the proposed legislation, if enacted and enforced, would put them out of business, and to this they felt strong objection. Realizing that the views of these men might be expected to have much influence with the committee, it was arranged that some of them should be heard when Captain Garden had finished.

The first of these gentlemen who was called upon had but one leg and used a crutch, but unquestionably he was effective. He expressed himself fluently and with great force. The committee and the audience listened attentively. In closing, he derided the suggestion that 3,000 volts was dangerous and exclaimed: "Why, gentlemen, the pennyroyal bulls of Fairfax County are far more dangerous than that current." I never learned what a pennyroyal bull is, but the committee seemed to feel that the gentleman had made a strong point.

The following morning, the committee met in the Senate room and representatives of local arc lighting companies in Virginia had the floor. Their opposition to the proposed legislation was unanimous and emphatic. The representatives of the Westinghouse company, realizing that such testimony from residents of Virginia might be expected to be more effective than any additional arguments they could present, introduced no further testimony. At the end of the morning session, which lasted only an hour or 2, the Senate Committee decided unanimously in disapproval of the proposed legislation.

Some months after the hearing at Richmond, Mr. Levis and I attended a hearing before a committee of the Legislature of the State of Ohio at Columbus, where a bill had been introduced similar in general tenor to that which had been rejected at Richmond. On this occasion, Harold P. Brown, a man much talked of in those days, appeared in support of the bill. Before the hearing, he had demonstrated the "deadly qualities" of alternating current by using it to kill 1 or 2 animals in the presence of a number of people whom he had invited to witness the demonstration.

At the hearing, Mr. Levis and I presented testimony in opposition to the bill and to Mr. Brown's statements. On this occasion, it was not thought necessary to call upon President Morton or Captain Garden. The efforts of Mr. Brown and his associates accomplished nothing at Columbus.

Attempts to prevent the use of alternating current by legislation—or by inducing the authorities to refuse a permit—were made not only at Richmond and at Columbus, but also at other places in the United States and Canada, but without success.

In his efforts to prevent the introduction of the alternating-current system, Mr. Brown resorted to measures that were strongly resented by Mr. Westinghouse and his associates. The newspapers were filled with articles describing the deadly nature of alternating current. In some way, Brown managed to purchase a second-hand Westinghouse alternator and he was supposed to have been instrumental in securing enactment of a law in the State of New York which provided that the death sentence in criminal cases thereafter should be carried out by electrocution. For this purpose, he strongly and successfully recommended alternating-current apparatus. The fight was a bitter one and was prolonged through several years, but, fortunately, had little ultimate effect upon the introduction and general use of the alternating-current system.

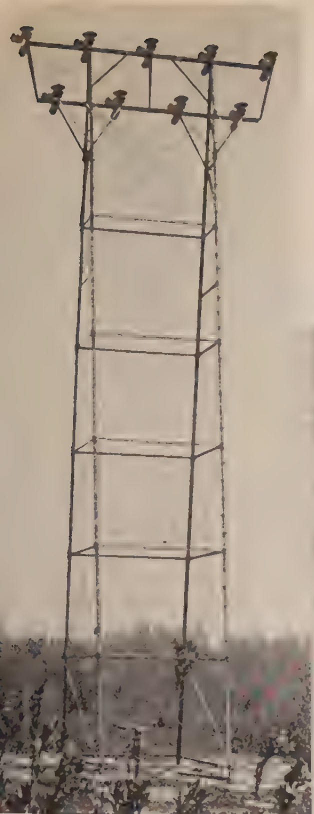
In 1892 the Edison Electric Light Company and the Thomson-Houston Company were combined to form the General Electric Company; and the opposition of the Edison interests to alternating current apparently disappeared. For several years the Thomson-Houston Company had been manufacturing and selling alternating-current lighting apparatus. Elihu Thomson, at a very early date, had experimented with the transformer, but his attention apparently had been centered upon its possibilities in electric welding rather than in lighting.

From the date of its formation, the General Electric Company energetically developed and exploited alternating current; and before the end of that year was competing vigorously and very ably with the Westinghouse company in that field.

Some Transmission Structures

(Right) Mill Creek-Redlands (Calif.) line (1892–3), reported to be the first 3-phase high-voltage (11kv) transmission line. Plant and line are still in service
(So. Calif. Edison Co. photo)

(Below) Modern 300-ft towers carrying 2 220-kv and 12 66-kv circuits over a navigable channel at the Long Beach (Calif.) steam-electric generating station
(Southern Calif. Edison Co. photo)



(Above) Original 60-kv line from Kern River hydroelectric plant to Los Angeles, Calif. (about 1902; suspension insulators added later
(So. Calif. Edison Co. photo)

(Below) The latest thing in transmission towers, the so-called rotated tower that is finding its first application on the 287-kv 200-mile line now being built from Boulder Dam to Los Angeles. Distance between outer conductors about 65 ft
(American Bridge Co. photo)

(Below) Left, Berkeley (Calif.) terminus of the first long distance transmission line to reach San Francisco Bay region; (right) modern counterpart built in 1923.
(Pacific Gas & Elec. Co. photos)

(Left) A 60-kv pole line of the old Standard Electric Co. (about 1902), that brought hydroelectric power from the early Electra plant in the Sierra Nevada Mountains (Calif.)
(Pacific Gas & Elec. Co. photo)

Developments in Electric Power Transmission

By Harris J. Ryan, President A.I.E.E. 1923–24

A brief account of some significant events in the history of electric power transmission related by a past-president of the Institute whose name is closely linked with many of those events and who for many years has been actively engaged in the study of high voltage phenomena.

DURING the early eighties through the studies of Kelvin we learned that economy in the transmission of an electric current would be greatest when the conductor loss and existence costs would be equal. No mention was made at the time of the voltage required for the corresponding economy in the transmission of electric power; that was to come later.

Promptly after his invention of the incandescent lamp, Edison developed in the early eighties the 220-volt 3-wire system with which continuous current could be transmitted economically a distance of a half mile to light incandescent lamps. Thus the industry of incandescent lighting was started in the business districts of New York, Boston, Buffalo, and Chicago.

The practical mind of another great inventor, George Westinghouse, soon became interested in the problem of increasing the distance to which incandescent lamps could be made available from a central power source. The result of his efforts led to the discovery of the practical availability of the transformer and with it the development of a 2-wire alternating current system for supplying current economically to incandescent lamps from a distant power supply. His plan included a generator with a voltage ample to transmit the current economically to the location of the customer where a transformer was placed to reduce the voltage to the amount required for the operation of the customer's incandescent lamps. The effect upon the incandescent lighting industry was immediate, and the practice was rapidly extended to large residential areas.

Early Electric Power Service

During the eighties, while the 220-volt incandescent lighting service was getting under way, no opportunity was overlooked to carry with it a power service with motors and an energy storage service with batteries. By the close of the eighties the advocates of the alternating current incandescent lighting systems felt keenly the want of satisfactory alternating current motors required for power service of many sorts, chief of which was the operation of conversion machinery required for the supply of continuous current and for charging storage batteries.

The alternating current incandescent lighting industries, in this epoch, were joined by many able men who quickly evolved satisfactory alternating current motors and the much desired conversion machinery. Thus the electrical exhibits at the World's Fair in 1893 demonstrated abundantly a world prepared at home and abroad to equip the incoming electrical age.

In the winter of 1886–87 William A. Anthony (president of the A.I.E.E. 1890–91) and his class of students in electrical engineering were received by Dr. Frank J. Sprague (president of the A.I.E.E. 1892–93) at his factory in New York City where he was engaged upon the notable work of manufacturing the motors for electrifying the street railways for the City of Richmond, Va. He showed us 2 of the $7^1/_2$-hp motors that were then completed for such purpose. In talking with Professor Anthony about electric power transmission, Doctor Sprague said he had found in his study that economy in electrical transmission of power would be directly proportional to the voltage and inversely proportional to the distance. This conversation made a profound impression on some of us who were thus started out in life with a never-ending enthusiasm for the study of high voltage phenomena required for the economic transmission of electric power.

The Battle of the Phases

The Niagara Falls-Buffalo, N. Y., 28-mile transmission was established in the early nineties at 22-kv between conductors. It had followed quickly on the heels of the great Frankfort-am-Mein electrical exposition, held in Germany in 1891, with its marvelous demonstration of a 100-mile 3-phase power transmission from a water fall at Lauffen to the exposition. The brief years that intervened between the Frankfort Exposition and the World's Fair witnessed the great economic-technical battle of the phases—3 phase versus 2 phase. The controversy invaded the counsels of the Niagara Falls-Buffalo power transmission development, when suddenly the contest was stopped by the master stroke of Charles F. Scott (president of the A.I.E.E. 1902–03) with his "T-connection" for transformers to connect 2-phase circuits to 3-phase circuits in balanced power relation.

The birth of the American Institute of Electrical Engineers in 1884 followed by the International Electrical Exhibition in Philadelphia during the same year, the Frankfort Electrical Exposition in 1891 and the World's Columbian Exposition in 1893

nade all America and much of Europe electrically ninded in regard to human communications and energy transmission and distribution with electrical facilities. These great electrotechnical activities and exhibits prepared world civilization to expect the early achievement of radio communication and the long distance transmission of power and its effective distribution.

To the youth of the late eighties and the early nineties there was visioned a rapidly changing world of extraordinary facility for communication and power development. For many it changed their entire outlook upon life. One great group promptly decided to be interested in power, soon to be followed by another group determined to find all they could do in the new field of wireless, later called radio. It has taken an entirely new generation to grasp the more recent outlook upon what to do with electrical facilities in geophysics, bionomics, and the long list of radiations having frequencies above and below those of X rays, also the more recent outlook upon the electrical opportunities for the social rebuilding of civilization in the electrical age.

Those in the power transmission group soon became preoccupied with their own chosen field and lost much of their former interest in what was going on around them. They became greatly interested and concerned with many difficulties encountered on their own road to progress. It soon was discovered that alternating current was an out-and-out necessity in high voltage power transmission because it made the simplicity of the transformer available. Much working enthusiasm was consumed in developing the requisite mathematical study for a satisfactory understanding of alternating current values and characteristic behaviors to be followed finally with a corresponding understanding of current and voltage transients.

In the midst of all this the limitations of the atmosphere as an insulator about the transmission line conductors was encountered in the middle and late nineties. Much thought and study were given to this matter by many power transmission engineers. Along with these difficulties with the atmosphere the practical limits of the single pin-type insulator soon were encountered. For years the power transmission industry was virtually forced to be content with 50- to 60-kv line insulators. The attempt to use higher voltages was not a success because the insulators then available would not "stand up" under the higher voltages. Again the day was saved with dramatic suddenness by the invention of the suspension type insulator. By the use of insulators of this type on a short line in Michigan in 1908 it was found that 110 kv, 3 phase, was entirely feasible.

This speedily was followed by the erection and successful use of a power transmission from a hydroelectric plant on the Feather River near the great storage reservoir, Lake Almanor, a distance of 140 miles to Oakland, Calif., with a terminal voltage of 90 kv. Shortly thereafter, a 3-phase line was erected to transmit power at 104 kv from a hydroelectric plant on the Stanislaus River a distance of 132 miles to San Francisco for the operation of the street cars of that city. This transmission was notable for having the magnetic and electrical constants of the conductors balanced so as to cause the line to operate at substantially the same voltage, 104 kv, at both terminals—generator and receiver.

What Frequency?

The development of hydroelectric power on a large scale at Niagara Falls forced the adoption of alternating current only to be followed by a great uncertainty as to the frequency to be used. Some urged that the magnetic activity of alternating current would preclude the use of all but those low frequencies that were successfully used in continuous machinery. Others in authority advised the use of 1,000 cycles per minute or 16.66 cycles per second because that was the frequency that was used in a 2-pole continuous-current generator running at a speed of 1,000 revolutions per minute. This same authority felt convinced that eventually much of the vast power to be developed at Niagara Falls would have to be applied to continuous current machinery and as direct current for electrolytic purposes. This authority finally was overruled by the controlling engineers and executives of the project who decided to launch it on a frequency of 25 cycles. The first large blocks of power to be sold from the new plant would require continuous current for aluminum reduction and for the operation of the street railways of the city of Buffalo. Makers' designs and tests had demonstrated the assured success of the 25-cycle synchronous converter thus permitting the adoption of that frequency.

Much work of all sorts remained to be done in the new industry. Hydroelectric power in abundance was available on the Pacific Coast and in the intermountain region involving transmissions to available markets over long distances. There quickly developed a need for standards in voltage and current wave forms, units for study and discussion, and application of inductance, capacitance, and leading and lagging reactive power. These needs were quickly supplied with few exceptions; one such was a choice of an intermediate frequency between the extremes then in use, 133 and 25 cycles, that would be more suited to the actual conditions existing in the Far West. It was greatly to the advantage of the hydroelectric power industry that the Far West was available for development closely following development at Niagara Falls. Various frequencies were tried: 40 cycles per second for Portland, Ore., 50 for Los Angeles, Calif., and 60 for the San Francisco Bay region. Fortunately the number of 40-cycle developments have been few and the mechanical differences between 50 and 60 cycles were not so large but that they could be overcome economically with advances in speeds of prime movers and frequency changers for interconnections between the ever-increasing 60-cycle systems in the Los Angeles region and the local 50-cycle practice.

Thus by 1915 the hydroelectric power transmission practice was stabilized at 60 cycles in the Far West, and elsewhere. Much support then was given to the study of the transmission technique required to

handle successfully power lines of indefinite length. Studies of voltage, power factor, and stability control and regulation soon visualized the feasibility, when needed, of the 1,000-mile 60-cycle power transmission line. These studies, however, preceded the great depression that developed in 1929. They had been made in the optimistic days of "reconstruction" that followed soon after the close of the great war—the years in which the transmission line voltages from the Big Creek hydroelectric stations to Los Angeles, 220 miles, were raised from 150 to 220 kv and the stations on the Pitt River were connected with 220-kv lines, 170 miles, to the markets of the San Francisco Bay region. During the depression years that followed 1929 the transmission engineers and their executives made intensive studies of the great rivals of hydroelectric power: the advances in steam power and the internal combustion engine using the available fuels, coal, oil, or natural gas. The purpose was to advance the economic balance of the nation's resources.

In some regions of the Pacific Coast water conservation, irrigation, and hydroelectric power must be coördinated for best economic results. In some of these regions the wisdom of ancient people who learned in the long past to live on irrigated lands, must not be forgotten. They learned that lands long irrigated become salted and that they must be restored to production by fresh water. Delta lands and low lands adjacent to the sea are likely to be invaded by sea water if the supply of fresh water by irrigation or otherwise is not ample.

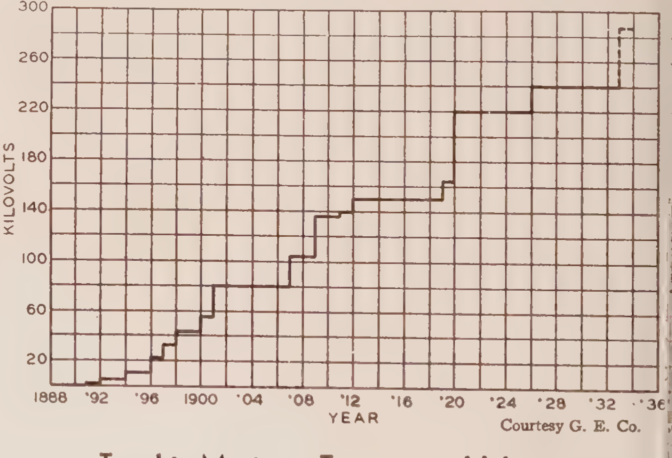
In general, power transmission engineers and executives are remaining alert in regard to the aggregate economics of power supply. This applies to the whole range of physical technique. Our civilization requires energy to carry on. For example, a 132-kv line will and does supply a power hook-up necessary for a synchronized, convenient, interchangeable, and economic supply of electric energy from point to point all the way from Chicago to the Atlantic and Gulf coasts. These points are supplied economically by hauling coal or by piping fuel oil or gas from the mines or wells. Substantially the same practice is developing on the Pacific Coast. This in effect amounts to a new type of power transmission and distribution. As such it is having a controlling effect upon the selection of voltages to be employed in new developments or extensions.

Far Western Conditions Determine Voltages

The December 1933 issue of Electrical Engineering reveals that power transmission engineers continue to learn from the Niagara Falls-Buffalo, N. Y., transmissions and from the Boulder Dam-Los Angeles, Calif., transmissions, that hydroelectric power conditions in the Far West continue to determine the advance in transmission line voltages. One of the remarkable things encountered through life has been the steady advances in voltage used for power transmission starting from the 10-kv single-phase pioneering in Southern California in the early nineties to be quickly followed by the 22-kv 3-phase Niagara Falls-Buffalo transmission. With a surprising approach to uniformity the transmission line voltage has advanced approximately 6 kv per annum, or 240 kv during the last 40 years leading to the projected use of 275 kv on the 300-mile transmission lines now being erected from Boulder Dam in Black Canyon, Colorado River, over the Mojave Desert to Los Angeles.

Through the half century of electric energy transmission for light and power, lightning has caused innumerable interruptions to service and much damage to equipment. A vast amount of study has been made of the origin and behavior of lightning. Real progress has been made in overcoming its hazards. Such studies and their results may be found in the A.I.E.E. Transactions.

All the nation has profited greatly by this exchange of benefit from power transmission and distribution on the extreme sides of our country and through its great interior valley. It is literally true that all the world has thus profited. Most authors of the narratives found in this May 1934 issue of Electrical Engineering will remember their days in college when it often was noted that the highest advances for students in physics, chemistry, and the applied sciences were to be made by European study. It has been a great satisfaction to many of these same authors and to others to find the United States now in readiness to repay such debt to Mother Europe. In recent years Commonwealth Fund fellows have come to our country for 2-year studies from Cambridge and the University of London, England, CRB fellows from Belgium (Commission for the Relief of Belgium Educational Foundation) and a Volta fellow from Italy for the study of electrotechnics in lectures, classes, laboratories, factories, and fields of practice in the United States. From our own experience we realize the profound effect upon these young men that sojourn among us will have. What will they do in Great Britain and the British commonwealths, in Belgium and the Belgian



Trend in Maximum Transmission Voltages

Congo, in Italy and North Africa? Perhaps the electrification of the Nile Valley and the transmission of hydroelectric power from the high level lakes in the Himalayas to Calcutta, India, will be among their achievements.

Water Power Development

By W. S. Lee,* President A.I.E.E. 1930–31

Although energy derived from water has been utilized by man for at least 3,000 years, its greatest development has come within the lifetime of the Institute and after the first hydroelectric "central station" was constructed at Appleton, Wis., in 1882—a "250-light" installation. Since that time the utilization of water power for the generation of electricity has expanded until now the aggregate installed capacity of hydroelectric plants in the United States is more than 15,000,000 hp. Some significant events in this development are outlined briefly in this article.

FROM the crude water driven devices of ancient days, there has developed one of our greatest and most economical sources of energy—the modern hydro-electric development. For at least 3,000 years the energy derived from water has served to lift burdensome tasks from the shoulders of mankind. Today energy derived from water power performs a myriad of tasks to an extent but yesterday undreamed of, thereby serving mankind in providing his needs—food, raiment, and shelter. To outline the course of development through the centuries, from the early current wheels that served the simple needs of grinding grain and lifting water to the modern turbine driven generators that serve the complex needs of civilization today over vast transmission networks, is not attempted in this article.

The origin of the water wheel is lost in the shadows of the past, although over 30 centuries ago current wheels actuated by the energy of moving water were in use on the Nile, Euphrates, and other rivers of the then civilized world. From these free current wheels were developed the undershot, overshot, impulse, and breast wheels which operated in restricted artificial channels so that the water could be directed and controlled and the water head utilized as well as stream velocity. The fundamental principles of the present day turbine—wherein the water acts mainly by impulse or reaction or both, and the velocity has a definite relation to the head—can be distinguished in water wheels constructed in the sixteenth century. The development of the modern turbine can be said to date back to the early part of the nineteenth century when the outward-flow turbine was developed by Fourneyron and the axial discharge type by Jonval and Henschel. The inward-flow turbine, in which the action of the Fourneyron turbine is reversed, was patented by Howe in 1836 and was greatly improved by Francis about 1847, who is regarded by many as the originator of this type. In the course of development radical departures have been made so that the modern Francis turbine is of a combined radial and diagonal inward-discharge type. Impulse wheels were an early development, the first major improvements being made about 1853 by Atkins and developed to extensive use by Pelton, who, in 1882 and subsequent years, made radical changes and improvements in design. This type of wheel is used extensively for high head developments.

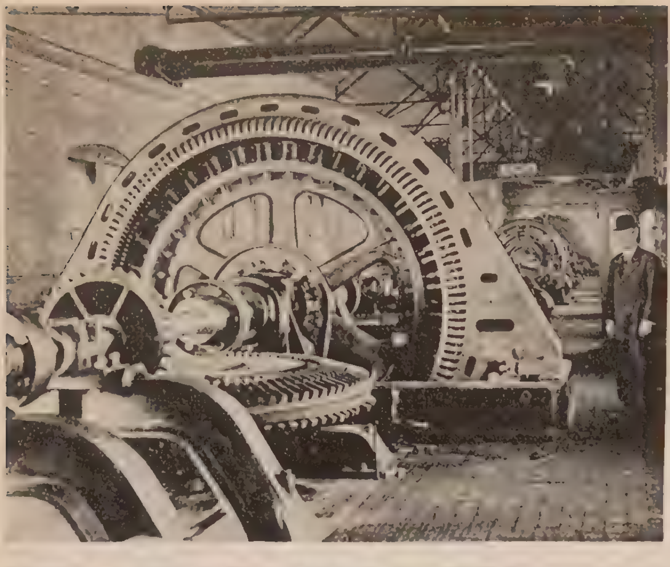
The first great water power development in the United States was made on the Merrimack River in 1822 near Lowell, Mass., followed by similar developments on the same river at Manchester, N. H., and Lawrence, Mass. These developments had capacities of 10,000 to 12,000 hp each, using a great number of wheels installed at factories along the various canals. These early developments followed by similar ones at Cohoes, N. Y., in 1828 and at Lewiston, Me., in 1849, were used chiefly by the textile industry which, due to the availability of water power, expanded at a rapid rate throughout the New England-New York area. In fact, this section of the country retained its predominating position in the textile industry until the extensive development of hydroelectric power together with other factors resulted in the movement of a large part of this industry to the South. The water power development of the Connecticut River at Holyoke, Mass., in 1848 and the developments of the Fox River in Wisconsin were devoted largely to paper manufacture. The water power of the Genesee River at Rochester, N. Y. (1856), and on the Mississippi River at Minneapolis, Minn. (1857), were utilized largely for the manufacture of flour. The year 1861 saw the beginning of development of power at Niagara Falls, a canal being constructed and in subsequent years water being delivered to various factories; in 1881 a central powerhouse was built, the energy being transmitted to a number of factories by means of belts, ropes, and shafts. In spite of the fact that the factory had to be brought to the power site and the machinery driven directly from the wheels, the utilization of water power continued to increase, there being in excess of 1,000,000 hp installed by 1870.

When the A.I.E.E. was organized in 1884, hydroelectric power was in an embryonic stage. An arc light machine had been installed at Quigleys Mill in 1881 supplying a few customers in Niagara Falls, and an installation of 250-light capacity had been made in 1882 at Appleton, Wis.; this latter generally is re-

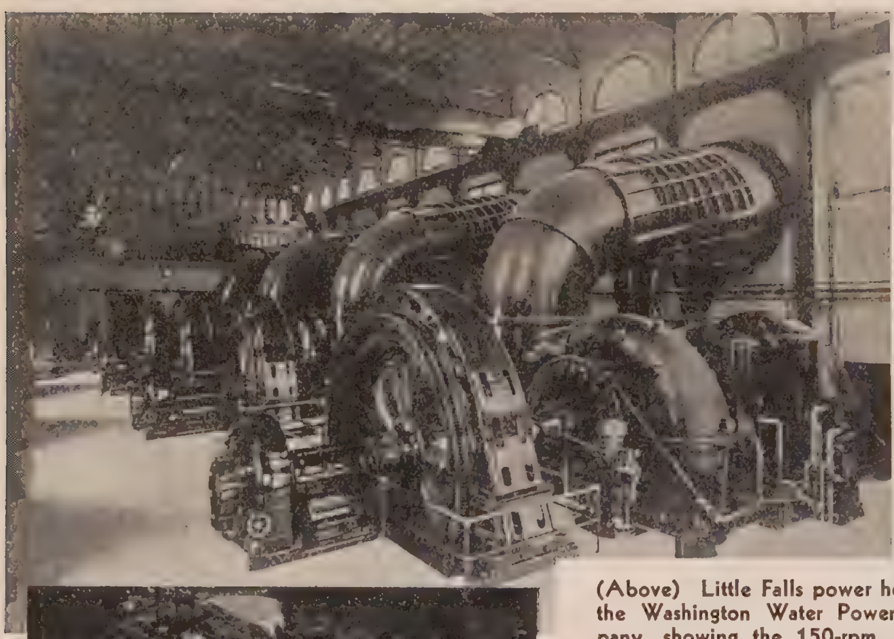
* Deceased March 24, 1934; see ELECTRICAL ENGINEERING, April 1934, p. 636.

Some Hydroelect

a



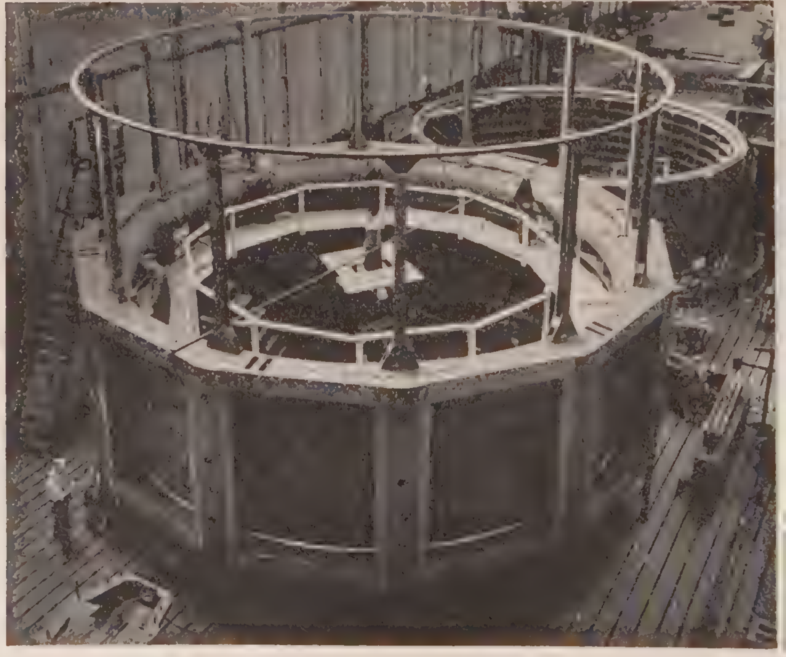
(Left) A 1,500-kva 200-rpm water-wheel plant of 25 years ago, showing the inefficient method of driving the machines then in use
(Electric Mach. Mfg. Co. photo)



(Above) Little Falls power house of the Washington Water Power Company, showing the 150-rpm, 4,000-volt 5,000-kva horizontal cast frame generators (1909–11)
(General Electric photo)

(Below) Shop assembly of the fir completed intake gate for the Bould Dam development. This lower gate 26 ft high and 37 ft in diameter, weigh ing 260 tons
(Westinghouse photo)

(Above) Twilight view of the 108,580-hp "Pit No. 3" hydroelectric station on the Pit River in Shasta County, Calif.
(Pacific Gas & Elec. Co. photo)



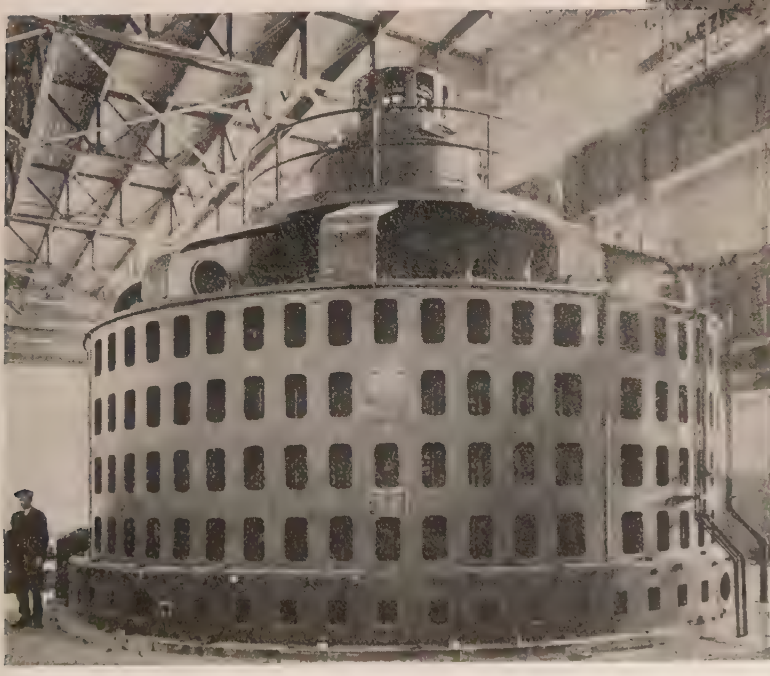
Power Stations Equipment

Old Colgate Plant on the Yuba River, Calif., from which the first 60-kv transmission line was constructed to Oakland, a distance of 110 miles
(Pacific Gas & Elec. Co. photo

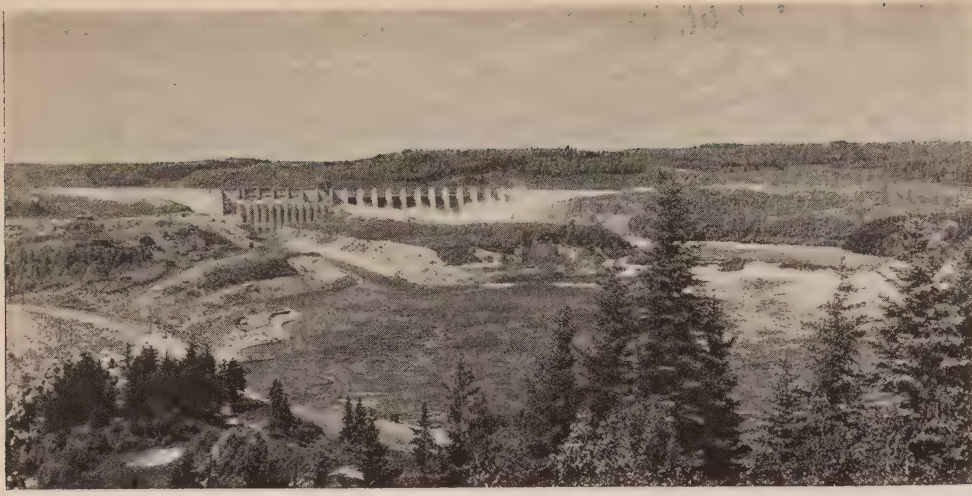
(Above) Generator room of the hydroelectric plant at Dnieprostroy, on the Dnieper River, U. S. S. R. These 5 units, each rated 77,500 kva, were the first to be put in service; 9 turbines to develop a total of 750,000 hp have been installed
(General Electric photo)

(Top) Old Brown's Valley hydroelectric plant which was constructed by the Yuba Electric Power Co., in Calif., in 1889; it is now abandoned
(Pacific Gas & Elec. Co. photo)

(Above) Mill Creek No. 1 plant (Calif.) as it appeared in 1902. This plant, which was built in 1892–93, was connected to what is said to be the first polyphase high-voltage transmission line, a 3-phase 11-kv line extending from Mill Creek to Redlands (16 miles). The original installation consisted of 3 250-kw 2,400-volt machines, one of which is still in operation
(Southern Calif. Edison Co. photo)



(Left) One of the famous Niagara Falls 65,000-kva 107-rpm 12,000-volt generators, with air discharge housing removed showing the cast frame construction
(General Electric photo)



Chute a Caron hydroelectric development on the Saguenay River, Canada, about 125 miles north of Quebec and operated by the Alcoa Power Company, Ltd. This development supplies power for the production of aluminum and newsprint

ferred to as the first U.S. hydroelectric central station. In 1889 the first alternating current hydroelectric installation, consisting of 2 300-hp water wheels belted to single-phase generators, was made at Oregon City, Ore., by the Willamette Falls Electric Company, power being transmitted 13 miles to Portland. In 1890 the Telluride Power Company installed at Ames, Colo., 2 150-kw 3,000-volt single-phase generators, directly connected to Pelton water wheels, power being transmitted 5 miles to Telluride. The years 1892–93 saw the beginning of long distance transmission of electric power at San Antonio, Calif., 800 hp being transmitted 28 miles to San Bernardino. In 1893, the first commercial 3-phase installation, consisting of 2 250-kw 2,400-volt Y-connected generators, driven by Pelton wheels, was made by the Redlands Electric Light and Power Company in southern California, power being transmitted $7^1/_2$ miles to Redlands and there used for both lighting and motor applications. During this same year a polyphase plant was installed at Hartford, Conn., 400 kw being transmitted 11 miles at 5,000 volts. No attempt has been made to include all hydroelectric plants constructed in the 10-year period from 1884 to 1894, but only those in the United States representing major innovations and developments. Plants were being projected and built throughout the country, there being about 300 in operation by 1896, and it is entirely possible that the ones referred to are not the first of their particular types.

The year 1895 marked the beginning of the modern central station era and the recognition of the supremacy of polyphase alternating current for generation and transmission when the 5,000-hp units began operation at Niagara Falls. The turbines for these units were of the Fourneyron type, double-wheel, outward discharge without draft tube, and operated at 250 rpm at a head of about 140 ft. The guaranteed efficiency of these turbines was 75 per cent at full gate opening. The generators were of the umbrella type, the rotating field element being external to the stationary armature, 2-phase power being generated at 2,000 volts, 25 cycles. In 1896, power delivery from Niagara Falls to Buffalo began, the initial use being about 1,000 hp for the operation of street railways. Power was transmitted at 11,000 volts, 3 phase, the distance being approximately 22 miles.

Utilization of hydroelectric power resources has proceeded at an ever increasing rate since 1895 and far-flung transmission networks have been evolved. Generating units have increased steadily in size: 31,000-hp units were in operation in 1916, 70,000-hp units in 1924, and at the present time 115,000-hp units are under construction. To transmit the ever increasing blocks of power over greater distances, the transmission voltages have been successively raised: In 1896 the maximum commercial voltage was 25,000 volts; in 1903 the first 60,000-volt line was installed; and by 1909, 100,000-volt transmission was an accepted fact. Since then, 132, 165, and 230 kv lines have been installed extensively and a line is now under construction to operate at 275 kv; the next step is 330 kv and this seems not far off.

Growth of Water Power Development in the United States 1869–1933 as Shown by Capacity of Water Wheels Installed at End of Year

Year	Horsepower	Year	Horsepower
1869	1,150,000	1919	7,590,000
1879	1,250,000	1920	7,800,000
1889	1,300,000	1921	8,050,000
1902	2,050,000	1922	8,270,000
1907	3,250,000	1923	9,090,000
1909	3,870,000	1924	10,040,000
1910	4,220,000	1925	11,180,000
1911	4,530,000	1926	11,720,000
1912	4,770,000	1927	12,296,000
1913	5,480,000	1928	13,572,000
1914	5,790,000	1929	13,808,000
1915	6,140,000	1930	14,885,000
1916	6,470,000	1931	15,620,000
1917	6,800,000	1932	15,802,000
1918	7,110,000	1933	15,930,000

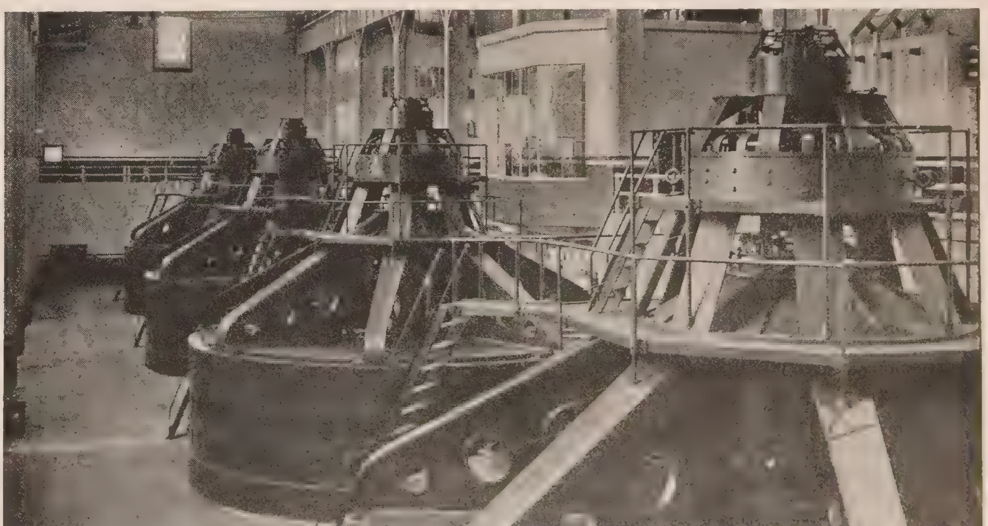
Not only has the size of individual units and of plants increased, but also the efficiency of unit, plant, and system has been steadily improved. Modern turbines in conjunction with the latest types of waterways, show efficiencies at rated load of well over 90 per cent even for low head plants and relatively small units; for the larger units, efficiencies of over 93 per cent have been obtained. Generator and transformer efficiencies have been improved, now being

in the neighborhood of 97.5 and 99.2 per cent, respectively, for large units. Transmission efficiencies due to unified system operation and proper design have been greatly improved. Thirty years ago a plant efficiency of 70 per cent was considered excellent; today 89 or even 90 per cent can be attained. Coördination of steam and water power resources, coördination and control of water storage facilities, coördinated operation of systems and the parts thereof, and coördination and coöperation to secure the maximum economic use of interconnection facilities between systems, have resulted in vast improvement in system efficiency.

The Duke Power Company, with which the author of this article has been connected since its inception, is taken as an illustration of typical power system development. Starting with one plant of 10,000 hp, which in 1904 began operation, generating and transmitting power at 11,000 volts, this system now has 598,000 kw in hydroelectric and 287,000 kw in steam facilities, the annual power generation being in excess of $1^3/_4$ billion kilowatthours. The transmission networks covering the Piedmont industrial area of the Carolinas consists of over 4,000 miles of circuits, approximately $^1/_2$ of which are 100-kv lines. Interconnection is made with adjoining power companies at several points where power interchange is economical and of mutual benefit. Of particular interest are the hydroelectric developments on the Catawba River, where 12 plants utilize over 90 per cent of the total head between el 140 ft and el 1,200 ft, and in conjunction with water storage facilities, provide almost complete regulation and utilization of the river. The Bridgewater, Rhodhiss, and Oxford developments on the upper reaches and the Catawba development located below the junction of the South Fork, have large storage reservoirs for retention of flood waters and excess river flow. The total reservoir storage capacity when utilized over the plants below amounts to 277 million kilowatthours; the development, construction, and coördinated operation of this vast storage with the run-of-river plants, steam, and interchange facilities, has been the result of careful study and a definite plan of procedure. The first development had a plant efficiency of about 70 per cent; many of the modern developments show plant efficiencies at full load of 88 to 89 per cent. Transmission efficiency has been steadily improved and for the year 1933 the efficiency of transmitted power from the generator terminals to the customer's meters was over 86 per cent. While this system has been discussed in some detail, it is but one of the many great hydroelectric systems whose transmission networks cover the nation. In the main, the story of one system is a story of all—maximum utilization of natural resources for the common benefit of power consumers and power producers.

Centralization and coördination of power resources have been effected solely for economic reasons: to give uniform and reliable service; to maintain and even lower power rates in the face of ever increasing costs; to make the investments sufficiently attractive that the properties can be financed; to afford the support of organizations highly trained in efficient planning, constructing, operating, and improving the systems and the parts thereof; and to engage aggressively in the development of additional power uses by domestic, commercial, and industrial consumers. Today the aggregate capacity of hydroelectric equipment installed in the United States is more than 15 million horsepower, generating about 35 billion kilowatthours annually; and the rate of increase is more rapid than for power generation by steam—from 1927 to 1932 installed hydroelectric capacity increased 37.6 per cent while the capacity of all prime movers increased 34.3 per cent.

While our great power industry as now constituted has contributed so much to the needs of mankind and has been such a great factor in the upbuilding of our nation, sinister shadows tend to stunt, if not to kill, future normal growth. We are faced not with constructive regulation for the greatest good to both power producer and power consumer, but with destructive governmental regulation, destructive governmental competition, and destructive taxation. Unless saner judgment prevails, this great industry will see its handiwork sacrificed to political ambition, political oppression, and political aggression—to the lasting benefit of none and to the detriment of all.



Interior of Chute a Caron station. The 4 units operate under a head of 150 ft and are rated 65,000 hp each

Some Reminiscences of Niagara

By P. M. Lincoln, President 1914–15

Although almost microscopic as compared with modern electric generators, the 5,000-hp generators installed at Niagara Falls in 1895 had a capacity of about 4 times that of the largest generator previously built. Some of the early operating experiences at Niagara are related here by a past-president of the Institute who was the first operating superintendent and who was in charge of the construction and operation of the original Buffalo-Niagara 11,000-volt 3-phase transmission line.

ELECTRICAL equipment of the Niagara Falls Power Company, which began operation in 1895, was unique in many particulars. First, it was unique in size. The electric generators installed at Niagara Falls in 1895 were of approximately 4 times the capacity of the largest previous electric generators that had ever been built. They were rated and were capable of carrying 5,000 hp. This rating is, of course, almost microscopic when compared with some of our present-day generators; but nearly 40 years have passed since the starting of the Niagara plant. I think I am correct in stating that the Niagara generators represent the largest *single step forward* that has ever been taken in generator design. It speaks well for the ability of their designer, Mr. B. G. Lamme, to note that these generators are still in operating condition and even now are used occasionally to carry a part of the Niagara Falls Power Company's load. That they have been taken out of regular service is not due to any deficiencies of the generators.

One of the farseeing innovations that Lamme introduced into Niagara generators was the use of mica as the insulation on the armature conductors. This choice of mica was fortunate. Tests made many years later showed temperature rises in the armature conductors that were totally unsuspected during the operation in the earlier years. These later tests showed temperatures of the order of 200 deg C under the heaviest loading conditions. The fact that Mr. Lamme's mica insulation stood up for many years under any such temperatures is not only a tribute to his genius in selecting mica as the insulation, but also is a commentary on the temperature measuring methods of that early day.

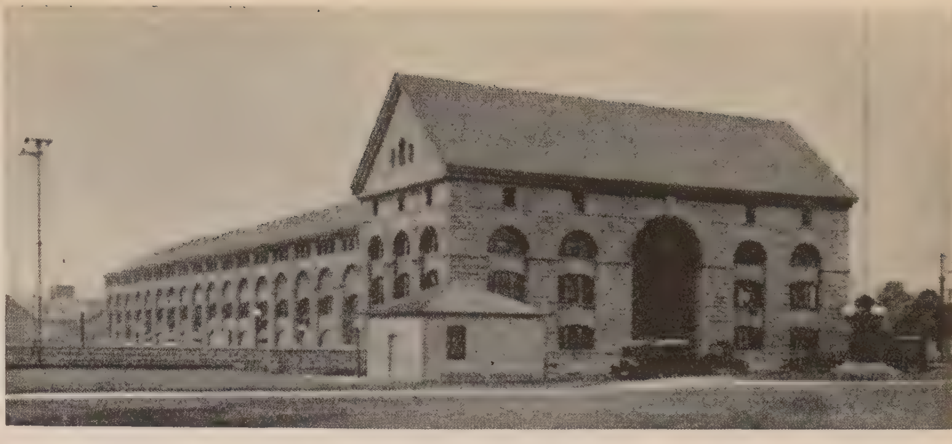
Another unique feature of the first Niagara plant was the design of the exciting system. While we can justly say that remarkable foresight and genius marked the design and construction of the first Niagara generators, the total absence of these qualities marked the design of the exciting system. It seems incredible, but it must be recorded, that the only exciters provided for this first Niagara plant consisted of rotary converters, which were to be run from the main bus bars. Fortunately, there was available in a neighboring building a direct-current steam-driven machine which had been used in connection with the construction of the wheel pit and water tunnels; this machine was used to excite the main generator for the purpose of starting the rotary converters that in turn were to be used for exciters. In case of an accident that would shut down the entire plant, we were helpless, of course, without this steam driven machine to enable us to start up again. For the first 2 or 3 years of operation it was therefore necessary to keep this steam driven machine either running or ready to run at a moment's notice, to guard against a total shutdown of the main plant.

A more unsuitable design for an exciter system could not be imagined. At the end of the first 2 or 3 years' operation, water wheel driven exciters were installed; and not until then were we free from the necessity of keeping this steam driven unit constantly ready for instant service. It is a commentary on the state of the art at the time that such an oversight could have occurred in the design of the exciter system.

Still another unique feature of the Niagara plant was the frequency adopted—25 cycles. The circumstances that led to the adoption of this frequency are set forth by Mr. Edward D. Adams in his "History of the Niagara Falls Power Company" (v. II, p. 236–8). As Mr. Adams points out, 25 cycles was a compromise. It is worthy of note, however, that 25 cycles became a standard frequency and was subsequently used to a considerable extent, particularly in the United States.

Niagara was unique in that it was primarily intended for *power* rather than *light* as were most of the preceding electric installations. It was one of the earliest and by far the largest electric power installation of the time. It was unique further in that the methods used for the generation and distribution of power were new and untried—at least on the scale attempted at Niagara—namely, *alternating current, polyphase*. Practically all the users of Niagara service were *power* users. The first user was what was then called the Pittsburgh Reduction Company, now the Aluminum Company of America. That plant started on August 26, 1895; it soon was followed by the Carborundum Company and soon after that by the Union Carbide Company. Other loads followed rapidly. The plant was suc-

Exterior of Niagara Falls power house No. 1



cessful from the beginning. There were troubles, of course, but none insurmountable.

Early users of Niagara power were local, located not over a mile from the power house. With the success of the local use of power, there naturally came consideration of its transmission to neighboring cities, particularly Buffalo. There was naturally quite some misgiving as to our ability to give satisfactory service in Buffalo, but this step was undertaken the year following the starting of the Niagara plant, that is, during the autumn of 1896. Many new problems arose in connection with the transmission of Niagara power to Buffalo. I think I can do no better than to quote from a report that I prepared some 15 years ago for incorporation in Mr. Adams' history of Niagara Falls.

[Editor's Note: The remainder of this article is republished from "Niagara Power, History of The Niagara Falls Power Company, 1886–1918," by Edward Dean Adams, v. II, p. 276–86. These 2 volumes were published privately in 1927 by the Niagara Falls Power Company, Niagara Falls, N. Y., on the fiftieth anniversary of its foundation.]

Report of Operating Superintendent

The supervision of the details of material and erection of the transmission line was the responsibility of the company's resident electrical engineer and operating superintendent, Paul M. Lincoln, who describes his work in this connection by the following statement made in 1920:

The first Niagara-Buffalo transmission line on the American side of the Niagara River went into service during the fall of 1896. As the operating superintendent for The Niagara Falls Power Company, it became my duty to supervise the operations of this transmission line from the time it went into service in 1896 until I severed my connection with The Niagara Falls Power Company in May 1902.

The status of electrical transmission as of that date has been set forth in the preceding chapters. Suffice it to say that at that date the use of alternating currents for lighting was only 10 years old and its use for power purposes was almost unknown. The few previous attempts to use alternating currents for power purposes were exceedingly crude and were on a much smaller scale than that proposed for the Niagara-Buffalo transmission.

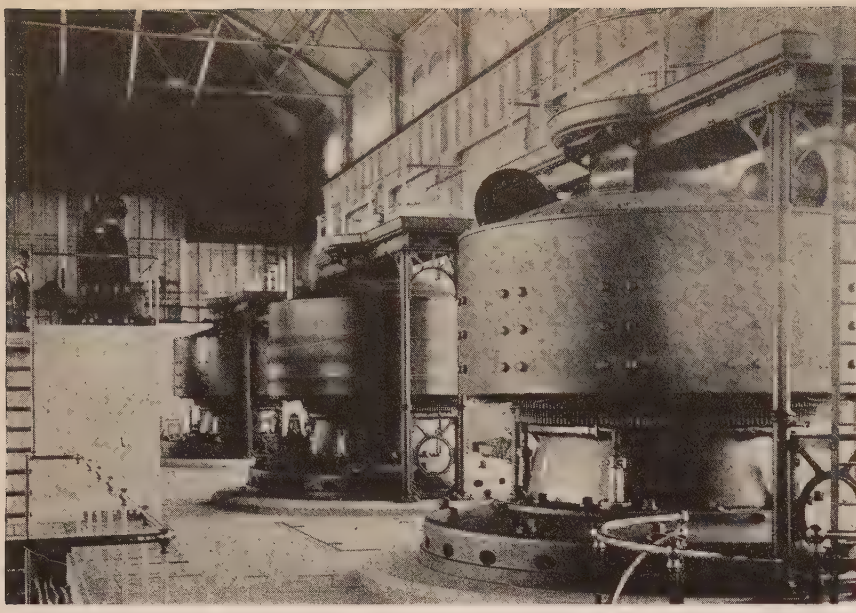
In the construction of the Niagara-Buffalo transmission line, such precedents as then existed were followed. These precedents in turn had followed the practice of telegraph construction—the only precedent there was to follow in that day.

The following statement is based on my personal recollections of 6 years' direct contact with this transmission, and is reinforced by the opportunity which has been afforded me of perusing the correspondence that passed at the time when the purchase of equipment for this transmission was contemplated.

The construction of the Niagara-Buffalo line followed the recognized practice of the period for telegraph lines—the only precedent there was to follow at that time. The poles, cross arms, pins, and insulators were of course heavier than those used in telegraph practice, also all poles on curves were either braced or guyed. At corners, double poles were used, but in other than these details construction was very similar to that used in the telegraph practice of the day.

The photographs reproduced herewith show but a single line on the poles; this is because these particular photographs were taken before the second line was erected. To meet the problem of continuity of service it was essential to have more than one transmission line available for use at all times. Two such lines were installed at the beginning, either one of which would easily carry all the power taken by Buffalo during the first few months or year. It was always the policy of The Niagara Falls Power Company to have a sufficient number of lines in service so that at any time one line could be shut down for inspection or repair and the remaining lines could easily carry all the power required.

The Niagara-Buffalo line was a relatively short one, only about 22 miles from the step-up station in Niagara to the step-down substation in Buffalo. Today this would hardly be called a transmission, but rather an enlargement of the distribution area. Also, the voltage used was not high—11,000 volts—3-phase—a voltage that today would be viewed as a distribution voltage. Other plants, even at that time, were transmitting power at higher voltage than that. However, in some aspects the Niagara-Buffalo transmission was unique and of historical importance. In the amount of power transmitted and in the importance of the service rendered by the transmitted power, the Niagara-Buffalo transmission transcended anything that had been attempted previously. The first load in Buffalo to be operated by this transmitted power was the street railways of Buffalo. Any failure of transmitted power was, therefore, heralded immediately throughout the entire community. Other loads were soon added which were almost as important. The first requisite for trans-



Original 5,000-hp 2-phase Niagara generators

Although the a-c system had been pronounced impossible for Niagara, these Westinghouse generators, built in 1894–95 and several times as large as previous a-c machines, are still operating. The external revolving field design prevailed for the first 10, then the internal revolving field was used.

mitted power was therefore *continuity*. It soon developed that the success or failure of Niagara power in Buffalo depended on keeping the supply *continuously* available in Buffalo. Then, therefore, began the long battle for *continuity of service*, a battle that has been waged not only on the Niagara-Buffalo line but on every other transmission line that has gone into service since then.

In 1896, transmission line equipment was not what it is today. Lightning arresters were totally inadequate; the oil switch was not yet known; the insulator was woefully defective and such a thing as reversed power protection was not even dreamed of. The experiences of the Niagara-Buffalo transmission were to have a material effect on the evolution of transmission technique.

Lightning

Lightning was one of the first as well as one of the most formidable enemies that the Niagara-Buffalo transmission had to fight. There never has been a complete answer to the lightning problem, but at that period there was hardly even a beginning to the later progress. The bettering of line insulation and construction has been one of the chief factors that has reduced interruptions from lightning. Nothing has been developed that has eliminated *all* interruptions from lightning and in my opinion there will be no such development. A direct stroke of lightning is almost sure to cause an interruption of service on the line affected; if, beyond this, equipment attached to the transmission line is not destroyed, the operators may consider themselves fortunate. Direct strokes, however, are not common and it is a lucky thing for the transmission of electric power that this is the case. But there are severe strains imposed on the insulation of transmission lines and the equipment connected thereto whenever lightning occurs anywhere in the neighborhood of a transmission line. The severity of these strains depends on the severity of the lightning discharge as well as its proximity. Against these indirect effects it is possible to secure some degree of protection. In 1896 the amount of protection that could be secured was an unknown quantity.

Alexander J. Wurts of the Westinghouse company had been doing valuable work on the problem of lightning protection. (See paper by Mr. Wurts, A.I.E.E. Trans., March 1892 and May 1894.) He had developed a so-called "nonarcing" lightning arrester, a series of cylinders made up of metal that would permit the lightning discharges to pass, but presumably would prevent the generator current from following. These arresters were tried out on the Niagara-Buffalo transmission line with considerable hope that they would perform as expected. However, it was soon found that the low frequency in use on the Niagara system coupled with the large amount of power in the installation back of the line, caused almost a complete failure of the so-called "nonarcing" properties of these arresters. An arrester which would operate with perfect success on a system of a few hundred kilowatts failed utterly to quench the arc when the Niagara generators were back of that arc. This was one of the points where the size of the Niagara system introduced a new problem. It was found that in order to make these arresters suppress the arc successfully it was necessary to introduce a resistance into the discharge circuit to limit the amount of current that could flow. This in turn limited the effectiveness of the arresters.

Both the Westinghouse and the General Electric companies worked ardently on this lightning arrester problem but neither was able to produce a complete solution. In fact it has always been a serious question in my mind if the lightning arrester on the Niagara-Buffalo line accomplished anything at all toward continuity of service. There may have been some occasions when the arresters took care of lightning surges that might have caused damage and interruption of service without them; also there were other occasions when the failure of the arresters to quench the generator current caused service interruptions that would have been avoided if there had been no arresters. The use of lightning arresters on transmission lines is still a mooted question. In general it has been found that the higher the voltage of transmission, the less necessary lightning protection becomes. With the very high voltage used in some of our latter-day transmissions, the voltage strains caused by lightning are but little if any higher than the normal voltage strains. The higher

the voltage used for transmission, the less necessary becomes lightning protection, due to the fact that the operating voltage requires so high an insulation. All this, however, was not known in 1896, and we at Niagara had to pass through the labor pains of the birth of this knowledge.

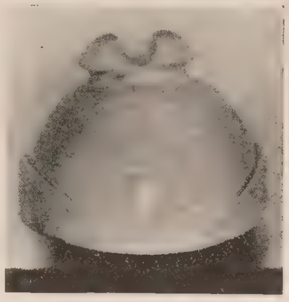
The design and construction of the first Niagara-Buffalo line incorporated one method of protection against lightning that proved disastrous. Theoretical considerations indicated that grounded guard wires over the transmission lines would be effective, at least to some degree, in shielding the transmitting conductors from lightning. Three such guard wires were installed on the original line. Unfortunately, however, the material selected for these guard wires was standard barbed fence wire. So long as the guard wires remained intact they were undoubtedly effective to a considerable degree in protecting the line. But the material of these guard wires was not equal to the strains put on them in this service and occasionally they would break and fall across the transmitting conductors below. This would cause a short circuit and usually a complete interruption of service. The worst of it was that often service could not be restored until the broken guard wires had been found and removed. Guard wires, therefore, were not found to be conducive to continuity of service in this case. After the experience of a few of these guard wires being broken, the guard wires were removed.

In passing, I might remark that this experience has not shaken my faith in the efficacy of guard wires as protection against lightning. It is still my opinion that guard wires properly installed constitute the best protection available against lightning; however, the "properly installed" should be emphasized.

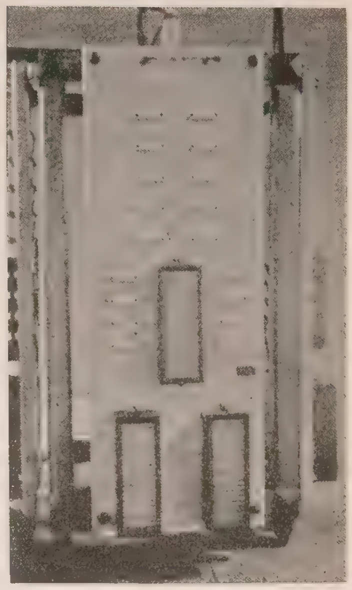
To recapitulate, lightning was probably the greatest single cause of service interruption on the Niagara-Buffalo transmission, partly because of the severity of lightning storms on the Niagara frontier and partly because of the insufficiency of knowledge in methods of combating the difficulty. Not a small part of this knowledge resulted from our experience on this particular transmission line. While we were not able to obtain perfect protection from lightning, the interruptions we were getting at the end of my 6 years' connection with the Niagara-Buffalo transmission were not so serious as at the beginning. We were continually getting the better of the problem of interruption by lightning. This is evidenced by a record of more than a year's operation without a single interruption of service from lightning or any other cause—a record that has been made by this Niagara-Buffalo transmission.

Line Insulators

The line insulator constituted another problem that we on the Niagara-Buffalo transmission had to meet and meet with but little previous experience to guide us. The early transmission lines followed the practice already set by the telegraph. The only previous departure from this practice had been the Frankfort-Lauffen transmission in Germany during 1891. In that installation, power had been transmitted from a water-power [station] at Lauffen to the city of Frankfort—a distance of about 100 miles. 30,000 volts was used in this installation—a voltage far above anything that had been used previously. The installation was not intended to be a permanent one. One of its main purposes was to advertise an exposition then going on in the city of Frankfort, and it was more or less of an experiment. The insulators used on this transmission were provided with an oil cup so designed that an oil covered surface was interposed into the path of any leakage current over the surface of the insulator. At that time, it was not considered practicable to use any other type of insulator on so high a voltage. It is also noteworthy to observe that in its earlier proposals for the insulators on the Niagara-Buffalo line (made either late in 1893 or early in 1894) the Westinghouse company proposed to use similar oil filled insulators. Apparently the oil filled insulator idea was later abandoned and both the Westinghouse and the General Electric companies proposed insulators of the general type later adopted. This is of interest as indicating the unsettled state of the transmission art at this early day. The drift of actual practice has been entirely away from the oil filled insulator. So far as I know, the Frankfort-Lauffen transmission was the only case in which oil filled insulators were ever actually used in power transmission, but they



Helmet type insulator used on original Niagara Falls-Buffalo transmission line

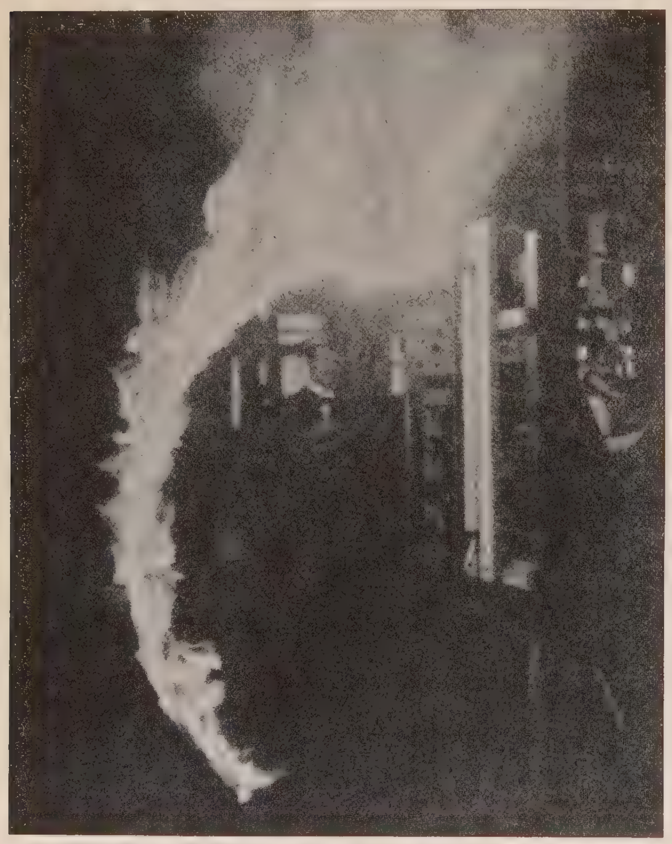


(Right) Wurt's lightning arresters at Niagara end of Buffalo transmission circuit, 1913

were seriously considered in 1893 or 1894 for use on the Niagara-Buffalo line.

There were a number of designs of insulators tried out on the Niagara-Buffalo line. In every case the material was porcelain, but the shape, size, and method of manufacturing differed. Among other types a large number of porcelain insulators made by the dry process were installed. These insulators were more or less porous and after some months of operation would absorb enough moisture to become slightly conducting. This in turn would lead to the burning of pins, cross arms, and pole tops. Many difficulties of this nature were encountered and

eventually all insulators of this type were taken down and rejected. To eliminate insulators of this character we developed the method of soaking them in salt water, using a salt water bath in which the insulators were partially immersed upside down and then filling the pin hole with salt water and applying the test voltage between the water in the pin hole and that of the bath. After this method of test had been adopted the defective porous insulators were quickly detected and rejected. In all about 40,000 of these dry process insulators were rejected in connection with this transmission. In many cases, however, the rejection did not take place until after the insulator had been in service for some time and had had the opportunity to contribute its quota against us in our battle for continuity of service.



Fuse-release 10-kv Niagara circuit breaker

Melting of a fuse released a hinged arm 4 ft long which fell, drawing a momentary long arc. This type was used on the early Niagara Falls-Buffalo circuit

Except for our disastrous experience with these dry process insulators, the porcelain insulators we used at Niagara were fairly satisfactory. We knew more about the insulator problem after our 6 years' experience than we did before, of course, and the design and construction of porcelain insulators received a decided impetus from this experience. It is worthy of note, too, that one of the modern underlying types of insulators—the Hewlett-Buck insulator (suspension type now almost universally used on high voltage lines)—had its origin in connection with the Niagara-Buffalo transmission line. This particular type of insulator was not used, to be sure, on this first line but the problems of this line induced its conception.

Switches and Protective Devices

In 1896, protecting devices for transmission lines were conspicuous by their complete absence. The oil switch had not yet been conceived and there was no method known by which a short circuit on an operating transmission line of the capacity we had at Niagara could be opened without shutting down the entire system. The only overload protection we had at the beginning of operations was fuses. It soon developed that the fuse under these conditions was a menace and not a protection. The amount of power to interrupt was so large that the fuses of that day could not begin to interrupt a short circuit successfully. After this fact had been demonstrated by several sad experiences, all fuses were removed. The only alternative was so to arrange that the entire plant would be shut down in case of a short circuit. This was accomplished by causing the field circuit breakers on the generators to trip in case a short circuit came on and persisted. Since most of the short circuits occurred on the Niagara-Buffalo line, it soon became necessary to separate the transmitted load from the local load so that an interruption on one need not involve the other. There were a great many more short circuits on the transmission line than there were on the locally supplied load and the local load users objected strenuously to being shut down every time a short circuit occurred on the transmission lines. Hence the separation of the 2 loads.

The necessity of shutting down the entire system whenever a short circuit occurred pointed strongly to the necessity of securing a switch that was capable of interrupting a short circuit. No such switch existed at that time and the problem was put up to the manufacturing companies for solution. The General Electric Company started the development of the oil circuit breaker while the Westinghouse company preferred a design that used long air breaks. As development proceeded and experience was accumulated it was apparent the General Electric Company had chosen the right path in this case. While air break switches might be satisfactory on the 11,000 volts that the Niagara-Buffalo line started with in 1896, it became evident as experience accumulated that with higher transmission voltages which was expected to be adopted within a few years, the air break switch would not be satisfactory. Even with the 11,000-volt transmission, their operation was far from satisfactory. I personally saw its operation on one occasion when a heavy short circuit caused the opening of one of these air circuit breakers. The arcs drawn were at least 6 feet long and maintained for nearly 15 seconds. The results obtained were so unsatisfactory that we went back to the method of interrupting the entire load in case of trouble.

One of the earliest models of the oil switch was brought to Niagara Falls by the General Electric Company for trial. The early trials indicated that

this method of attack would be successful—and experience later proved this to be the case. Today, no one would think of using anything but an oil switch with voltages and amounts of power such as we were dealing with at Niagara. The General Electric Company was the first to make a move toward using oil to quench the arc in switching, but soon after it had proved successful the Westinghouse company followed and today not only these 2 companies make this type of equipment, but many smaller companies also. The significant thing which I wish to emphasize here is that when the Niagara-Buffalo line began operations, there was no known method of successfully interrupting a short circuit. Our only method of procedure was to shut off the entire power supply under that condition. It was one of the handicaps of being a pioneer in the transmission game. This particular handicap was a very serious one since our battle at Niagara was to secure *continuity of service.* By the method of operation we were obliged to adopt, every short circuit on the transmission system meant a total interruption of power. It was, therefore, our endeavor to reduce the short circuits on the transmission line to a minimum.

Before leaving the subject of switching, perhaps a word concerning the first switchboard installed with the original generators might be in order. One of the items of this board was a series of air operated switches. When these switches were designed and built in 1894–1895 they were the best that the art afforded. It was confidently expected that they would be able to interrupt any load that might be thrown upon them. However, it required but a very brief experience after the first generators had been put into operation to realize that these switches would be totally useless to interrupt short circuits. They were used as synchronizing and disconnecting switches but beyond that they were useless.

In passing it might be observed that this problem of interrupting short circuits on the very large capacity high voltage modern transmission lines has proved to be one of the most difficult that the transmission engineer has met. The oil switch has proved the best means of meeting this problem that has been found, but even the largest and most powerful oil switch made is taxed to its utmost with some of our larger power systems behind it. Continuity of power supply requires that some means be used to disconnect defective portions of a transmission system and allow the remainder of the system to go on supplying service to the unaffected portions of the system. The need of such a switch was recognized in the early days of the Niagara-Buffalo transmission but we had to struggle along without it.

Interruptions From Miscellaneous Causes

Two other causes of service interruption were met on this Niagara-Buffalo line, *viz.*, accident and malicious mischief. While accidents were not common, they did occur occasionally. For instance, on one occasion a dredge operating in the canal, along which ran the transmission line, raised its dipper into the line, thereby short-circuiting the line and temporarily shutting off Buffalo's power. On another occasion, a cat crawled in behind the lightning arresters in the step-up transformer station and caused a complete short circuit and shutdown. Another very peculiar case occurred when a gang of men were cleaning the right-of-way from trees. A tree being felled, struck the end of a crooked limb lying on the ground and caused it to ricochet into the air; by an unlucky chance it fell across the transmission line and lodged there. The limb was green and just conducting enough to carry some current from conductor to conductor. The limb on the conductors confined this current to the point of contact and the burning continued until the transmission conductor itself was entirely burned apart and fell to the ground. This accident not only interrupted power supply to Buffalo, but it completely disabled that line until repairs could be effected. On still another occasion lightning caused an arc to form between the transmission conductor where it emerged from the step-up substation at Niagara and the edge of a metal canopy that had been erected to protect the conductors at their point of entry. This arc continued until the conductor was burned in two.

Original Niagara Falls-Buffalo 3-phase 11-kv line

Some little trouble was caused by malicious mischief makers. The ubiquitous small boy found that he could cause a very spectacular display of fireworks by throwing a piece of wire over the transmission line. He little realized that he thus deprived momentarily a whole city of its power supply. Proper coöperation with the local police authorities along the line reduced this mischief to a minimum.

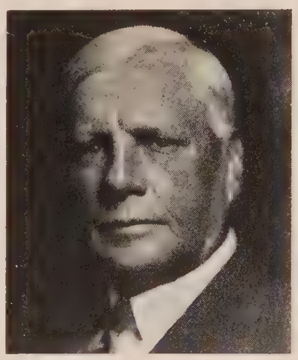
I might go on indefinitely giving instances of the difficulties that we encountered on this early power transmission. They all lead to one conclusion; we were pioneers and we suffered the fate of all pioneers. The road we were traveling was not yet illuminated by the light of experience. We had to grope our way. We were not wholly unsuccessful in lighting the way for others to follow. The Niagara-Buffalo transmission was a success both from a financial and from an engineering standpoint. The battle for continuity of service was waged and won. It has always been a matter of no little self-satisfaction that we at Niagara have helped to blaze the trail that since then has become a much traveled highway.

Some Contributions to the Electrical Industry

By C. C. Chesney, President A.I.E.E. 1926–27

Some outstanding individual contributions of the past 50 years to the electrical industry are reviewed here by a past-president who himself has made no small contribution; he says: . . . "as we of the electrical fraternity hope for continued progress, we must remember that our hopes can be fully realized only by remaining true to the greatest of our traditions, 'to produce and to serve.'"

As we look back into the history of the electrical industry and visualize the past 50 years, we can hope, yea, expect that future accomplishments in the electrical world will be fully as eventful as the unmatched events of the past. Promises that come from home and abroad are filled with predictions of continuous progress.



This optimistic sentiment, emanating not from one but from all of the many responsible sources throughout the world, applies not only to the business side, but also to the scientific side of the industry—to the central station business for furnishing light and power, the core of the industry with its investment values already reaching the $10,000,000,000 mark, a value greater than the combined value of the industries of England of the Gladstone period when Michael Faraday made his fundamental discovery of magnetic induction in 1832. It applies also to the possible future accomplishments of the research laboratories, forecasts of which are to be found in the accomplishments already given to the world by these institutions.

These forecasts are full of hope, so far as it is given to fallible man to read the future, and they may well bring pride to the heart of the electrical engineering fraternity as well as to the whole world. Coupled with that pride is a spirit of gratitude on the part of the present generation of engineers toward those who have given their lives and their leisure in establishing the fundamentals on which electrical science and industry are built.

In that spirit I am prompted at the outset to dwell upon the versatile achievements of Thomas A. Edison. However, as my association has been entirely with that part of the art which had to do with the manufacture of generating machinery for the transmission of power by the use of alternating currents, I propose to review the early history of the electrical profession for outstanding individual contributions peculiar to the development of the science and art of transmitting power by the use of alternating currents.

The salient feature of the art of generating and distributing power at the present time is the superpower system, that is, an interconnection of existing and prospective generating and distributing systems. The broad idea of the superpower system must continue to grow more and more, because it is economically sound. It brings about an improvement in the load factor of the generating system; it allows the metropolitan markets for power to be connected in a continuous system with remote power reserves, and makes the exchange of energy from one part of such a system to another a practical, reliable, and everyday occurrence. Many are the engineering problems involved in the safe operation and satisfactory service of an interconnected system. However, electrical engineers already have solved these problems or are well advanced in their solution. For instance, the spreading of the troubles of one system to the next (bugbear of the past) is prevented by proper relaying and sectionalizing.

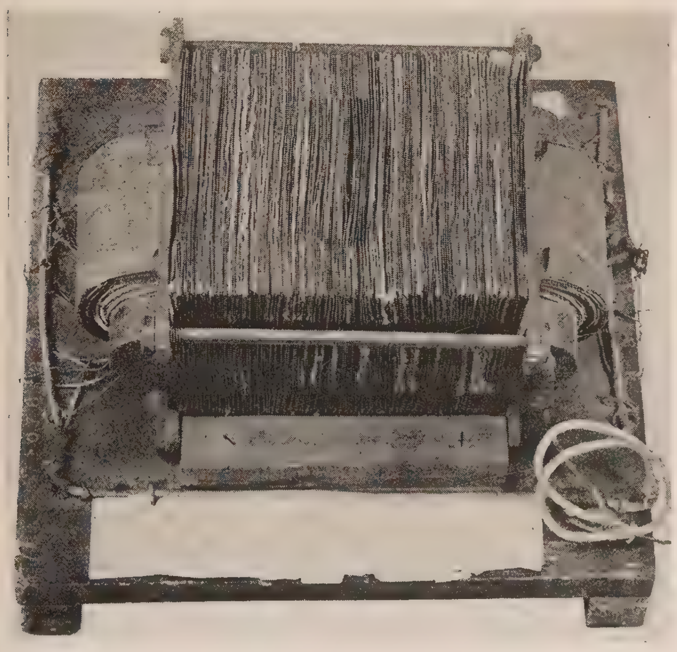
The holding of the proper voltage at different points, and the prevention of the flow of wattless current, are accomplished by adjusting automatically, if necessary, the ratio of the transformers so that the voltages at the point of connection may be of the same value and have the same phase relations. The interconnection of electric systems constitutes also an important progress in civilization, because it aims to allow electric energy, like sunlight, to become available everywhere.

It is well known that a discovery in the sciences is not an isolated event. The laws of nature have ordained that progress or change is never by leaps or revolutions. This is true, of course, of electrical engineering and the branch of it that deals with long distance transmission of power by means of alternating current. It has grown as does a snowball, by the process of almost infinitesimal additions. Practically every experiment or new development in the generation, transmission, and conversion of electric power is a modification of an experiment that has gone before. Almost every new theory is built through the contributions of many workers, of many different elements, one adding a little here and another a little there; thus to the observer in retrospect, progress seems to be continuous and uniform.

I wish, however, to emphasize the fact that the changes introduced into the art during the early '90's of the last century by the engineers of that period have placed the whole structure of electrical art of today as applied to light and power, firmly on the use of alternating currents. These changes have made economically possible the generation of large amounts of power in suitably located central stations, and its conversion and transmission to those points where it can be used most advantageously by

industry to operate and to increase the capacity and the economy of our mills and factories; to provide electrical transmission to the small town and country; to extend and improve the processes of metallurgy; and now to place in the homes of the great agricultural classes, through the use of electric power, the comforts and conveniences of the city, and to place in the hands of the farmer the opportunity to extend the economy of the farm to a point where it may compare favorably in efficiency and effectiveness with the factory and the workshop. Thus will the nation be prepared, through the aid of the superpower systems, for a complete decentralization of industry, which is needed ultimately to relieve the economic stress of both farm and city.

Nevertheless, to me the outstanding accomplishments of this period which made for the greatest progress were: the broad generalization of electrical phenomena, and the mathematical formula for the design of alternating current machinery by Charles P. Steinmetz; the invention and development of the modern transformer by William Stanley; the invention of the induction motor by Nikola Tesla;



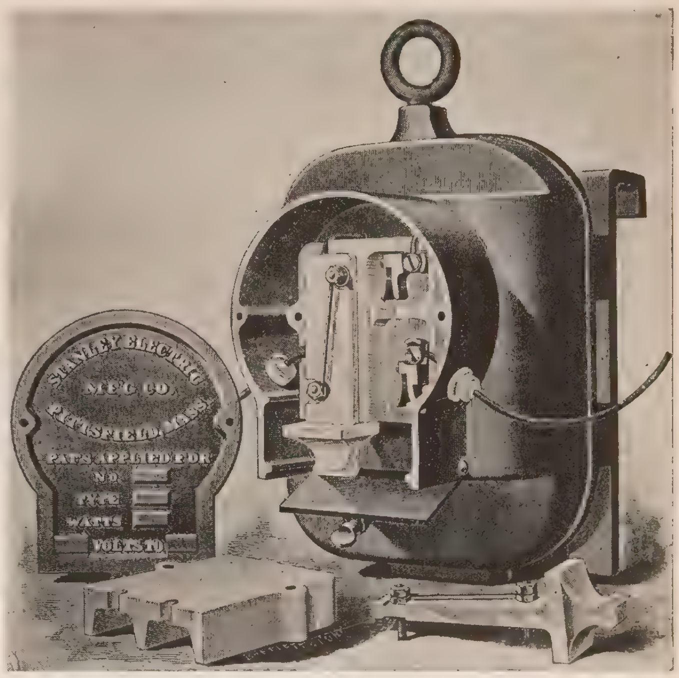
The original transformer built by William Stanley in 1885

the induction meter by Oliver Shallenberger; the dynamo-electric machine by Benjamin G. Lamme; and the numerous contributions to all branches of electrical machinery by Elihu Thomson.

In 1886, William Stanley, in the first alternating current plant in America, which was engineered and built by him at Great Barrington, Mass., demonstrated how electric power could be generated at a low voltage, transformed into a higher voltage, transmitted at the higher voltage, retransformed to a lower voltage, and used at this voltage as might be required. This feature of adapting the voltage to varying requirements, and of maintaining it substantially constant, irrespective of the load, rendered possible the enormous development and progress in the distribution and transmission of electric energy that have taken place since.

This capability of voltage transformation lies in the transformer itself, insignificant though it may appear. Stanley always spoke of the transformer as the "heart of the alternating current system." Naturally the great development of the art has been accompanied by a similar development of the transformer. Very early Stanley had properly visualized the fundamentals of transformer design, and correctly solved many of its problems in the Great Barrington installation. This revealed a thorough understanding on his part of electromagnetic induction, rather surprising for 50 years ago. The same ability in handling these laws as applied to transformers was shown by Stanley in the construction of the inductor alternator, which had no windings on the rotor, a feature considered of much value at the time. The inductor alternator, as well as the Stanley induction motor and the Stanley induction meter, did not survive; but the transformer did, and is substantially the same as the one originally built by Stanley.

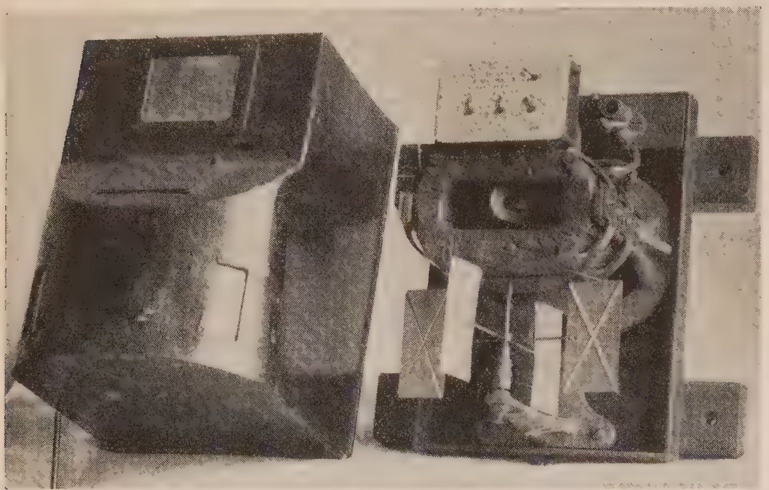
The possibilities of the alternating current system early appealed strongly to the imagination of electrical engineers, both at home and abroad, but they appealed to none more strongly than to William Stanley. At 30 years of age he had a full conception of the alternating current station idea of manufacturing power, that is, the manufacture of power in



An early Stanley commercial transformer with front plate removed showing arrangement of fuses

large volume in some suitable location, transmitting and distributing it to points of consumption by the use of alternating current. With this idea firmly fixed in his mind, and fully determined to find out at

Pittsfield, Mass., whether there were any limits in sight barring the use of line potentials higher than the 2,000 volts then generally employed, he instructed me to design and build, in 1892, transformers and a line for 15,000-volt operation. To this end we erected a pole line, built a transformer house, and set up the transformers. These increased the potential of the town circuit from 1,000 volts to 15,000 volts. We connected the line to this high potential supply, sent the current around a farm and back to the same transformer house, then retransformed the line potential to 1,000 volts, and operated the distribution transformers of the local company. This little plant was operated during a New England winter with entire success, and the engineering data obtained were the reason for subsequent recommendations by the Stanley Electric Company for the use of potentials much higher than 15,000 volts. I recall these facts only to emphasize the undeveloped state of the art of that early period of which I speak, and how limited and provincial was its outlook compared with our present-day accomplishments.



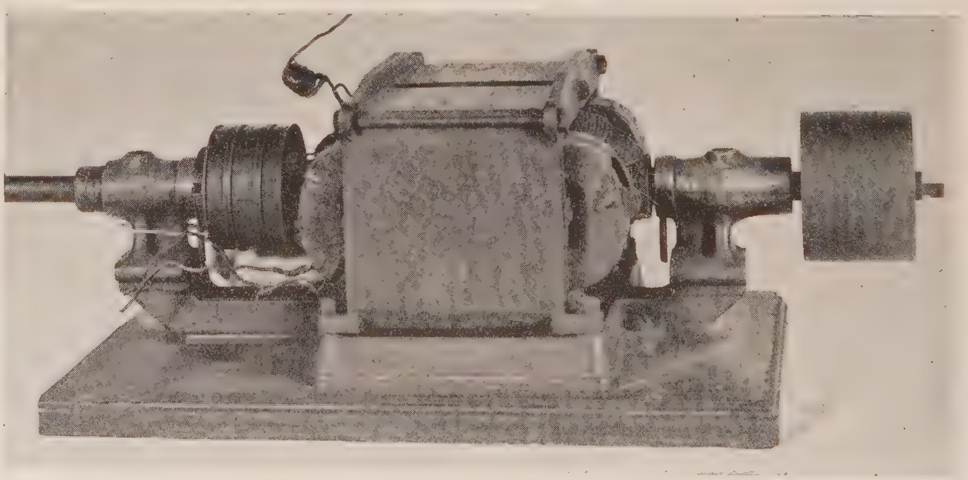
Westinghouse Photo

Induction type ampere-hour meter invented by Shallenberger in 1888. This was the first a-c integrating meter, and it is the parent of all a-c watthour meters now in use

Nikola Tesla invented the induction motor in 1888. This invention was a great step forward, and it has been stated frequently that the invention of this motor was one of the greatest advances made in the industrial application of electricity. This statement without doubt is true, but the development of the motor was long and costly, and as late as 1895 it was still in the experimental stage. Vital reasons for its slow progress, development, and application were: First, it was primarily a polyphase motor, and the alternating current plants of the day were single phase; second, these plants operated at a frequency of 133 cycles per second, and subsequent studies revealed that this frequency was not well suited for that type of motor. By 1895, however, its development through the aid of many other electrical engineers, was far enough advanced so that a good commercial motor became available.

The invention of the induction meter by Oliver Shallenberger was vital and important in the growth of the electrical industry. Until the invention of this interesting and much needed device, there was no instrument to measure the quantity of alternating current supplied to the consumer. While the meter operated on the same fundamental principles as the Tesla motor, Shallenberger invented the meter entirely independently of Tesla. While Shallenberger was observing the movement of a spring in an alternating current arc lamp, under the influence of a shifting magnetic field, the idea of the induction meter came to him. Within 2 weeks after he had conceived the idea, he designed and built a most successful alternating current meter of the induction type. This meter was accepted immediately as a success by the electrical industry and the public—a long time before the induction motor was accepted as such. While Shallenberger's particular meter has long been discarded, its influence on the development of the struggling industry was great indeed. He died in 1898, before he had an opportunity fully to appreciate or to enjoy the success of his labors.

The engineering talents of the late Benjamin G. Lamme, an engineer and inventor endowed with unusual ingenuity, resourcefulness, and good judgment, presented to the art the synchronous converter, the rotary condenser, and also the electrical design of the 5,000-hp generator—a far bigger generator than had ever been built up to that time—



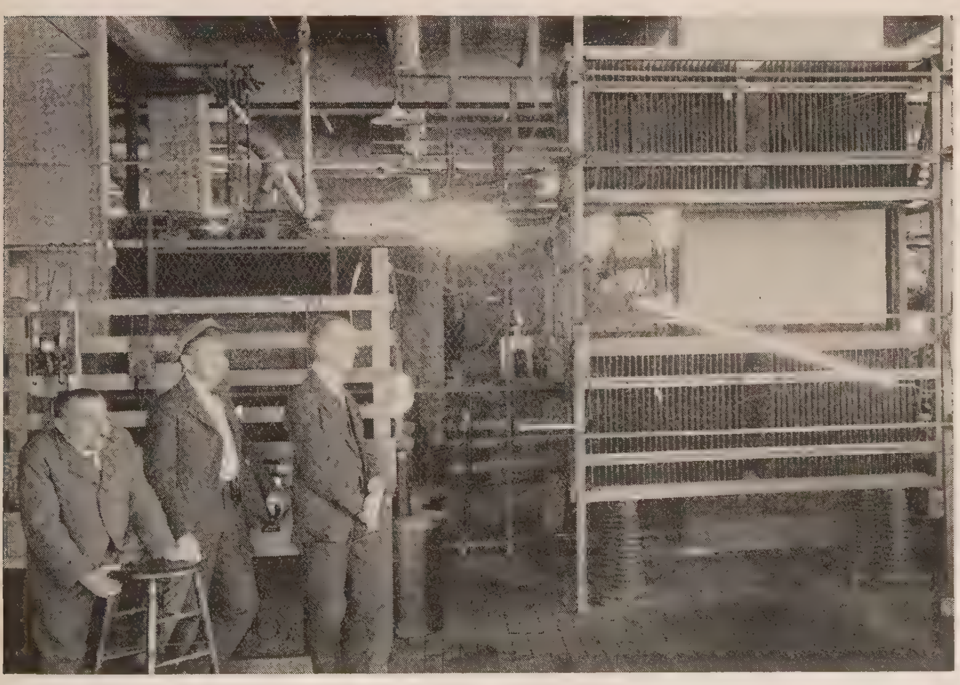
Westinghouse Photo

Early laboratory model of Tesla motor with wound rotor and slip rings

which inaugurated the hydroelectric power development at Niagara Falls in 1895. This type of generator has persisted to the present day. The single-phase railroad motor and the introduction of the squirrel-cage induction motor with high starting torque, were the individual works of Mr. Lamme.

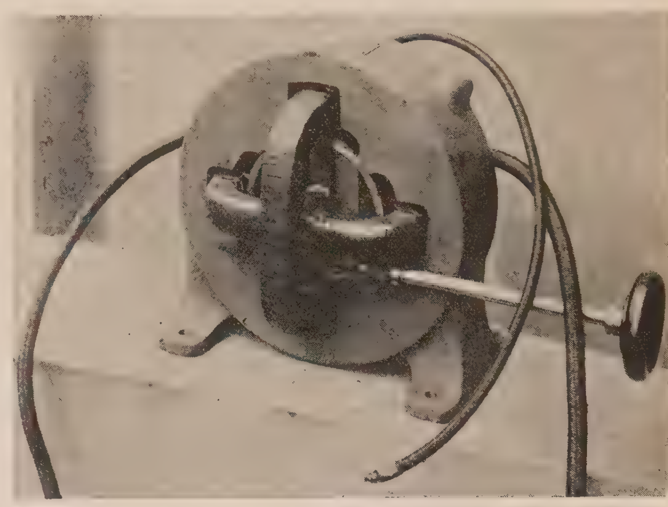
Of the contributions of Charles P. Steinmetz there is little to tell electrical engineers; they all know, and they knew him and recognized him among the leaders of modern science. His personal contributions to the science and the art of long distance power transmission by alternating current were many and valuable. To me, however, it has always seemed that his greatest contributions to the electrical art of our day were his writings, embracing the results of theoretical and experimental scientific investigations. In these is laid an invaluable mathematical foundation for the design of electrical machinery. His work in this respect has no equal in our day.

Elihu Thomson's contributions to the electrical industry have been so many and are so generic in character that it is almost impossible to select any one contribution from his work of the last half century which overshadows in importance and value any of his others. His remarkable depth and range of scientific knowledge have influenced in a major way the development in every field of electrical endeavor. A master of industrial research, he invented many early types of lightning arresters, magnetic blowout switches, the induction regulator, and the single-phase repulsion motor. From a power transmission and distribution standpoint, one of his most important contributions was his proposition to use oil for insulating and cooling transformers, a practice now universal the world over and upon which the success of the progressive and ever increasing power transmission potentials has depended.



Steinmetz observing artificial lightning flash in his laboratory, February 1922

I have selected these men as the most outstanding among all the electrical engineers and inventors of that pioneer period, the closing decade of the last century; their accomplishments more than those of any other group, made possible the high state of the art of transmitting and distributing electric energy as we find it and as we enjoy it today. It was through their insight into, and their solution of, the technical problems that beset them, and by their foresight in reading the future promises of their time, that they were able to blaze the trail not alone for their contemporaries, but for future generations as well. It was their glory to be able to catch a glimpse of what was before us while the rest of the world wondered. On the traditions of the past, a great future for electricity and for the transmission of electrical energy is predicated. However, as we of the electrical fraternity hope for continued progress, we must remember that our hopes can be fully realized only by remaining true to the greatest of those traditions, "to produce and to serve," and by cherishing the ideals and emulating the ceaseless activities of such pioneers as those mentioned.

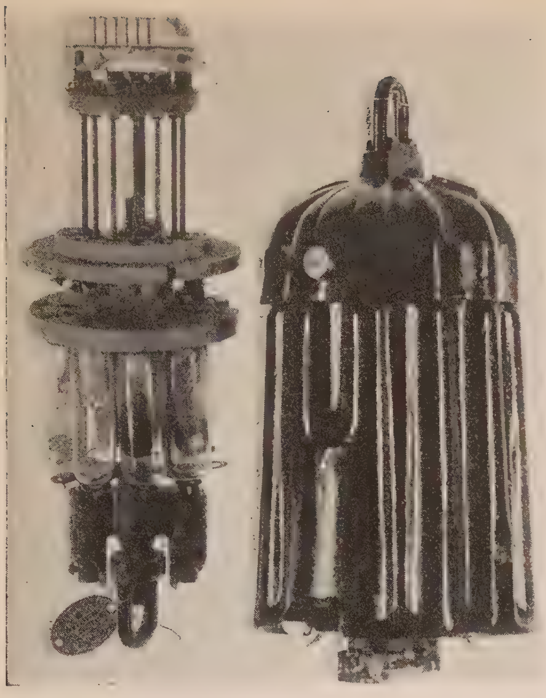


Thompson induction regulator of the late '90's

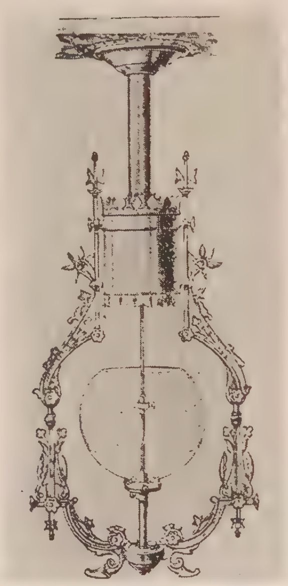
All 6 of these men possessed the scientific spirit. They were truly men of research, with patience and vision, always seeking earnestly and hopefully for new knowledge, more fully to understand Nature's laws as they are, and more effectively to use those laws for the benefit of humanity.

Some Early Forms of Electric Lamps

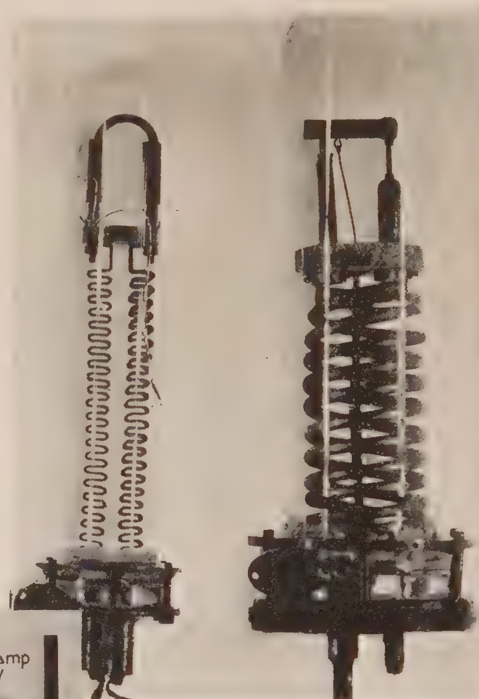
Arc lighting, now practically nothing but a memory, was the electrical industry's first commercial load. The fortifications of Paris were arc-lighted in 1870; in 1875 arc lamps came to America (Wallace Farmer system) where commercial success began about 1880 under the developments of Brush, Thomson-Houston, Weston, Waterhouse, and others. The incandescent lamp, however, and particularly since the development (1906) of metallized filaments, has waged a winning battle. Although, of the total present power output in the United States, lighting accounts for only about 25 per cent, as late as 1912 it constituted half the central station load



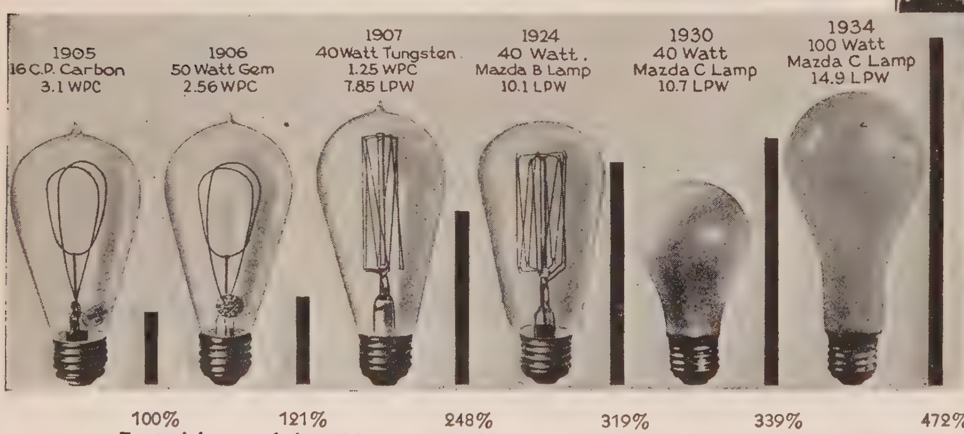
The Nernst lamp (above), more efficient than the early carbon filament lamps, burned in the open air and bade fair to win wide acceptance until succeeded by the Mazda
(Westinghouse photo



Right—An early design of ornamental open carbon arc lamp for interior use (list price $65!)
(General Electric photo)



Early forms of incandescent lamps said to have been in operation almost a year before Edison developed his commercially practicable incandescent lamp
(Westinghouse photo)



Typical lamps of the 1905–34 period, and an indication of the improved light efficiency of incandescent lamps
(General Electric photo)

Left—from left to right—the "stopper" lamp that lighted the 1893 Chicago Fair; Weston lamp, Weston base, 1882; U.S. Lamp Co. lamp, Weston base, 1882; Sawyer-Mann lamp, 1879, Thomson-Houston base
Westinghouse photo)

Right—Edison lamp first commercially used; carbonized bristol board "horseshoe" filament; produced Nov. 1879–May 1880; total height $8\frac{1}{16}$ in., bulb diameter $3\frac{15}{16}$ in.
(General Electric photo)

Lighting "A Century of Progress"

By W. D'Arcy Ryan,* Associate A.I.E.E., General Electric Co., Schenectady, N. Y.

Since the Columbian Exposition at Chicago in 1893 gave to the world its first large outdoor display, electric illumination has played a vital and striking part in the great expositions. At San Francisco in 1915 the illumination was classed by the International Jury of Award as a "Decorative Art"; at Chicago in 1933 the lighting was conceded to be an outstanding feature of the exposition in spite of the fact that it was almost an afterthought. In this short article the author gives a general description of the exterior lighting effects; illustrates some of the equipment used and the results obtained. —Editor.

IN JANUARY 1933, approximately 4 months before the opening date of the Exposition, engineers of the General Electric Company and the Westinghouse Electric & Manufacturing Company were commissioned to complete the exterior lighting of Chicago's *A Century of Progress* exposition. Obviously, the lighting of a group of buildings of ultra-modernistic or futuristic design such as those comprising the exhibit buildings at this exposition introduced many problems in lighting if the daytime architectural character was to be preserved at night. The late Joseph Urban, with his flair for bold color treatment and effects and ably assisted by his associates Teagan and Scott had skilfully used color to vitalize and unify the grouping of the buildings for daytime effect. At night the medium by which to accomplish these same ends was light.

Many engineers and designers contributed to the accomplishment of the lighting results, aided by the tireless and efficient efforts of many contractors in constructing and installing the equipment. I should like to mention by name these many engineers, designers, and contractors who are entitled to share in whatever credit attaches to the results obtained, but I fear that if I were to attempt to formulate such a list I should overlook many worthy contributors. I feel obliged, however, to acknowledge the work of E. D. Tillson who during the period that he was associated with the exposition as illuminating engineer laid the groundwork which proved very valuable to us who followed, and R. E. Barclay whose enthusiastic studies in the application of the gaseous conductor tube resulted in many striking and beautiful effects by these light sources. To C. W. Farrier and his staff is due the credit for the design of many of the lighting standards and much helpful and constructive criticism of the lighting scheme. The installation of the lighting equipment, including the design and installation of the entire electrical distribution system, was under the capable supervision of J. L. McConnell, electrical and mechanical engineer of the exposition, whose willing coöperation made it possible for us to overcome many obstacles.

In this paper I shall confine myself to a general description of the exterior lighting effects, and trust that a more detailed description of the numerous elements entering into the general scheme will be recorded in the technical press by those responsible for their development. Also, although consideration of the lighting of the building interiors and of the exhibits and exhibitors' buildings is outside the scope of this paper, I want to pay tribute to those responsible for the design and execution, for to my mind these lighting effects in many instances exceeded those of the exterior.

The exposition site (Fig. 1) contains approximately 424 acres and forms a strip along the shore of Lake Michigan approximately 3 miles long and varying in width from 450 to 3,200 ft. Northerly Island is separated from the mainland by 2 lagoons covering approximately 80 acres. In view of the attenuated shape of the grounds we regarded it to be a function of the lighting to consolidate the grouping of the buildings and create the appearance of a unified whole. Also, owing to the generally low types of buildings prevailing, it became a secondary consideration in planning the lighting to elevate, psychologically the exposition when viewed from the many points of vantage throughout the grounds. The buildings were of an entirely new style of architecture compared with expositions of the past, presenting large flat surfaces painted in a wide variety of colors, and with viewing terraces at many levels and therefore demanding an entirely new approach from the standpoint of lighting the buildings themselves and the surrounding grounds. The probability of fog and smoke became a factor of consideration in the determination of surface brightnesses and probable viewing distances. All these considerations and many others including a limited budget entered as compromising factors into the determination of the most appropriate and most efficient type of lighting equipment, a detailed description of which would require more space than is warranted here.

The exterior lighting—which we may consider under the topics of building floodlighting, grounds lighting, and spectacular lighting—made up a total connected load of approximately 3,000 kw. Power was purchased from the Commonweath Edison Company and distributed through the secondary network 4-wire Y 120/108 volts. Mr. McConnell has stated that in only one imperative consideration is the electrical installation at *A Century of Progress* directly comparable to ordinary engineering work,

* Deceased March 14, 1934; see p. 636, Electrical Engineering, April 1934.

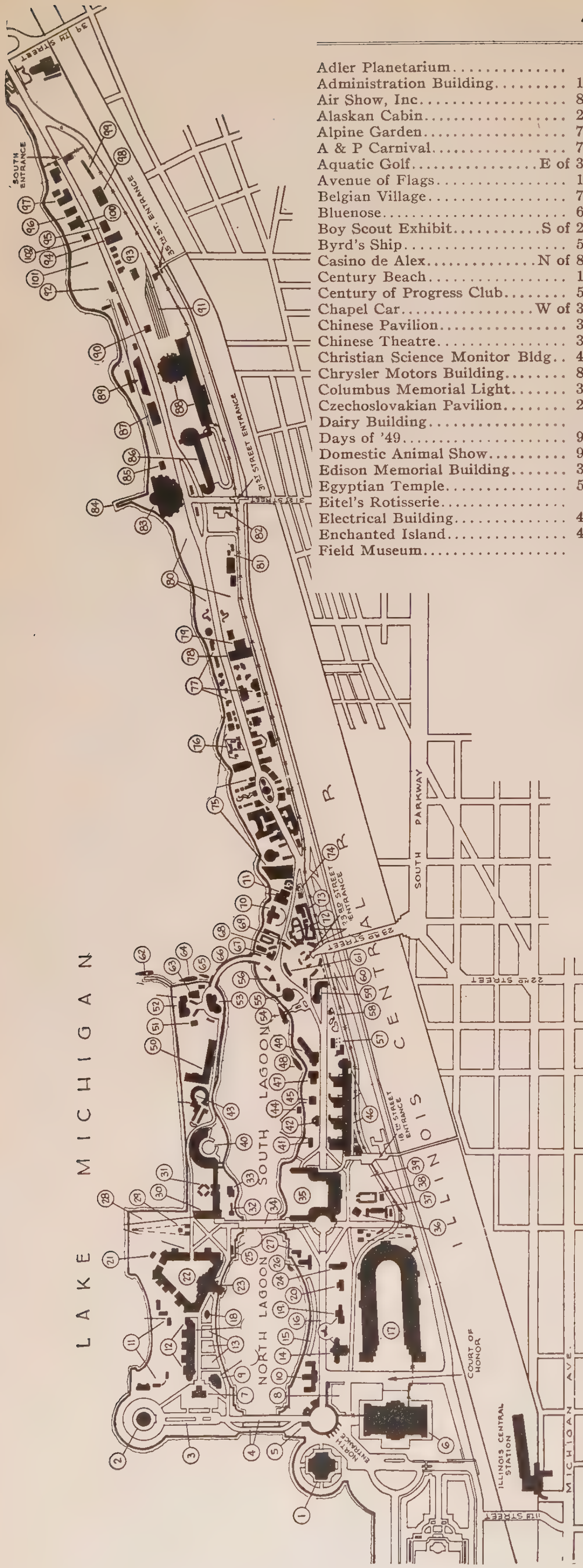


Fig. 1. Plan of "A Century of Progress" exposition grounds along the lake front at Chicago, Ill. (For key see adjoining column.)

Alphabetical Key to Exposition Plan

Adler Planetarium	2
Administration Building	10
Air Show, Inc	87
Alaskan Cabin	21
Alpine Garden	74
A & P Carnival	70
Aquatic Golf	E of 30
Avenue of Flags	16
Belgian Village	73
Bluenose	65
Boy Scout Exhibit	S of 21
Byrd's Ship	54
Casino de Alex	N of 87
Century Beach	11
Century of Progress Club	53
Chapel Car	W of 36
Chinese Pavilion	38
Chinese Theatre	38
Christian Science Monitor Bldg.	45
Chrysler Motors Building	86
Columbus Memorial Light	32
Czechoslovakian Pavilion	24
Dairy Building	9
Days of '49	94
Domestic Animal Show	95
Edison Memorial Building	33
Egyptian Temple	51
Eitel's Rotisserie	5
Electrical Building	40
Enchanted Island	43
Field Museum	6
Firestone Building	59
Florida Gardens	13
Foods and Agricultural Building	12
Fort Dearborn	76
Garden of Comfort	57
Gas Industry Hall	79
General Cigar Company Exhibit	69
General Exhibits Group	46
General Motors Building	83
Goodyear Field	92
Grand Stand	15
Great Beyond	96
Greyhound Service Station	98
Hall of Religion	49
Hall of Science	35
Hall of Social Science	30
Havoline Thermometer	56
Hollywood	52
Home and Industrial Arts Group	77
Home Planning Hall	78
Horticultural Building	50
101 Ranch	101
The Hub—Henry C. Lytton & Sons	61
Illinois Host House	19
Indian Village	81
Infant Incubator	67
Italian Pavilion	26
Italian Restaurant	27
Japanese Pavilion	37
Lama Temple	36
Machinery Demonstration Area	91
Maya Temple	82
Mexican Village	100
Midway	75
Miller High Life Fish Bar	18
Moroccan Village	72
Muller Pabst Restaurant	47
Norwegian Ship	64
Old Heidelberg Inn	71
Outdoor Railway Exhibit	91
Pabst Blue Ribbon Casino	53
Palwaukee Amphibian Ramp	85
Picnic Grounds	28
Planetarium Bridges	4
Poultry Show	93
Radio & Communications Bldg.	31
Rapid Transit Terminal	8
Receiving Depot	99
Rolleo (Log Rolling)	102
Schlitz Garden Restaurant	25
Science Bridge	34
Sears, Roebuck Building	14
Shedd Aquarium	1
Show Boat	44
Sinclair Prehistoric Exhibit	58
Sky-Ride	29
Soldier Field	17
Solomon's Temple	11
Spoor's Spectaculum	63
States Building	22
Streets of Paris	68
Submarine S-49	E of 26
Swedish Pavilion	20
Terrazzo Promenade	3
31st Street Boat Landing	84
Time & Fortune Building	41
Travel & Transport Building	88
23rd Street Bridge	66
23rd Street Steamer Landing	62
Ukrainian Pavilion	97
U.S. Army Camp	80
U.S. Government Building	23
Whiting Corp. & Nash Motor Bldg.	90
Walgreen's Store	60
Wings of A Century	89
World A Million Years Ago	55

"Century of Progress" Outdoor Lighting Standards

(See facing page)

A Floodlighting standard. Equipped with 18 200-watt floodlights. Installed around Planetarium, west side of Electric Building, and west side of the Hall of Science.

B Clover leaf standard. Equipped with 45 8 x 18-in. opal glass cylinders with 200-watt multiple mazda lamps and 3 200-watt floodlights. Installed at 12th Street entrance and in General Exhibits Building courts.

C Floodlighting standard. Equipped with 16 200-watt floodlights. Installed around Travel and Transport Building.

D Lantern standard. Equipped with a 6,000-lumen series mazda lamp. Installed along Lief Eriksen Drive.

E Mercury-neon pylon. Equipped with 48 mercury arcs and 48 neon arcs. One unit installed in Court "A" of General Exhibits building.

F Opal glass pylon. Containing 144 100-watt multiple mazda lamps. Four units installed in east court of the Hall of Science.

G Stair lighting unit. Small size, equipped with 26 60-watt multiple mazda lamps. Large size, equipped with 76 60-watt multiple mazda lamps. Installed at 23rd Street entrance and at various other locations throughout the grounds.

H Zodiac standard. Equipped with 18-in. opal glass ball and 500-watt multiple mazda lamp, surrounded by a bronze band depicting the characters of the Zodiac. Installed along approach to the Planetarium.

Fig. 2. Some "Century of Progress" outdoor lighting standards

(For description, see facing page)

and that is that it had to be made safe. Many interesting and novel features were introduced into the electrical distribution system by Mr. McConnell, many of which he has described in the April 27, 1933 issue of the *Electrical World*.

The colored plates forming part of this presentation (beginning facing page 736) afford a general idea of the appearance of the exposition at night. Obviously, they lack the intricacy of detail visible to the visitor who viewed the exposition on the grounds, and similarly any description of the lighting is lacking in the details of application so important in obtaining the results. The floodlighting of the building facades was accomplished in general by floodlights either located on the buildings themselves or grouped on structural standards of appropriate design and screened from direct view. All floodlights were of the enclosed type, ranging in capacity from 200 to 1,000 watts. In many instances the floodlights were equipped with colored door glasses, as it was found that much better results were obtained in flooding colored surfaces with light of approximately the same color as the surface. A wide range of colors, having coefficients of reflection of from 4 to 71 per cent, were encountered in the large flat composition-board surfaces of the various buildings. The viewing distances were relatively great. Many of the buildings had balconies serving as promenades. The atmospheric conditions peculiar to the Chicago lake front were, at times, very unfavorable. These conditions influenced the lighting treatment of the different buildings and made each one a subject of study and trial. Difficulties in concealing the lighting equipment were overcome by constructing screens or shields harmonizing with the building architecture where possible.

Gaseous tube lighting of building exteriors had its debut at this exposition and made possible many interesting and beautiful effects. A variety of gases and combinations of gases together with colored glass tubes provided the many colors used throughout the grounds. In general these tubes were applied in such a manner as to conceal the tube itself and to reflect the light from the building surface. One outstanding exception to the use of the tube for indirect lighting, and one of the most striking features of the lighting, was the "cascade" formed at the rear of the electrical court in which approximately 4,650 ft of blue tube was used. An innovation in the application of gaseous tubes was the use of the mercury-neon pylon rising 38 ft above the ground, triangular in section and constructed in louvre form to provide coves for the light sources. Alternate louvres on each face were equipped with mercury arcs and neon arcs. These arc lamps were of the hot cathode type, and operated as half wave rectifiers from an alternating current source, thus making it necessary to start the lamps each half-cycle.

These arcs, in common with all arcs, have a negative voltage characteristic. That is, after they are started, the voltage across the arc decreases as the current increases, at a rate and to a minimum depending upon the constants of the circuit in which the arc is established. This necessitated a ballast, and in this case an induction ballast was used which served also as a starting transformer. Two turns of high voltage insulated wire were placed around each reactor, and all the reactors on one phase were connected in series by means of this primary winding. Starting was accomplished each half-cycle by discharging a condenser through a thyratron tube into these series turns, the time of the discharge being controlled by means of a motor driven timer in the grid circuit of the thyratron.

When starting occurs late in the cycle the effective light is small and, *vice versa*, if the starting is earlier the effective light is greater. Taking advantage of this characteristic, a great variety of tints thus were obtained by controlling the dimming of the 2 sets of lamps in orderly sequence and thus obtaining changing proportions of neon and mercury light. In order to reduce the flicker to a minimum the number of lamps on each phase were kept balanced on each of the 4 faces of the tower. Individual lamps produce 60-cycle flicker, but the composite light on the buildings shows no appreciable flicker.

The problem presented in lighting the grounds and roadways also was influenced by the radically different type of architecture employed at the exposition, and resulted in the design of an entirely unique group of lighting standards. Efficiency of light output suffered very little in developing these futuristic lighting standards; in fact, most critics will give them a higher rating as lighting units than as objects of beauty. A general idea of these stand-

"Century of Progress" Outdoor Lighting Standards

(See facing page)

I Tubular lamp standard. Equipped with 100-watt 32-in. tubular multiple mazda lamps. 22 lamps for single plane standards and 44 lamps for 2-plane standards. Installed along the Avenue of Flags.

J Mushroom standard. Equipped with 150-watt multiple mazda lamp, refractor, and micarta shade. 500 units installed throughout grounds.

K Shell globe standard. Equipped with 500-watt B. F. multiple mazda lamps and shell globes. Installed around Dairy, Agriculture, States, and Electric buildings.

L Shower standard. Equipped with 352 15-watt flame-tint medium-screw-base multiple mazda lamps. 10 standards installed in the Court of States.

M Rainbow standard. Equipped with 4 500-watt floodlights. Installed in Lief Eriksen Drive at south end of grounds.

N Bridge standard. Equipped with a 500-watt floodlight. Installed on 12th Street bridge.

O Lighting Turrett. Equipped with 24 1,000-watt floodlights to illuminate reflecting surface, and 8 24-in. 1,500-watt incandescent searchlights for illumination of flags. Installed in center of 12th Street entrance.

P Tree lighting unit. Equipped with 6 200-watt floodlights. Installed at bases of trees throughout grounds.

Fig. 3. Some "Century of Progress" outdoor lighting standards

(For description, see facing page)

ards may be obtained from Figs. 2 and 3 and the related brief descriptions of their equipment.

General lighting throughout an exposition must be consolidated if the exposition is to stand apart as a unit. This was particularly true of Chicago because of the elongated form of the grounds and its adjacency to the city with its electric signs, illuminated buildings, etc. Efforts in this direction took the form of a battery of 24 36-in. arc searchlights located at the southern extremity and spreading a fan of light beams over the grounds, a battery of 17 36-in. incandescent searchlights fanning out from the electrical building, and a group of electric fountains, 3 in the south lagoon and 1 in the court of the Electrical Building. The 3 fountains in the south lagoon were located approximately 100 ft off the west shore and 150 ft apart. The center fountain, containing 70 incandescent floodlighting projectors arranged in four colors, was flanked by 2 fountains, each containing 36 similar projectors in clear light. The water effects were identical and were operated in synchronism by means of thrustor valves actuated through a central controller. The color changes in the center fountain were accomplished by means of a thyratron reactor system controlling the 4 circuits of red, green, blue, and amber light in a sequence of combinations the complete cycle of which required 10 minutes to complete. Each fountain circulated 1,200 gal of water per minute; the connected lighting load was 18 kw each for the 2 clear-light fountains and 67.5 kw for the central fountain. A 75-hp motor direct connected to a centrifugal pump supplied the necessary water from the lagoon. The fountain in the electrical court had a 3-step central basin at the center of a pool 60-ft in diameter. The water effects at each level consisted of a spray emanating from a circular ring of jets; the water was illuminated by static colored light, each level in a different color. These bands of color were reflected from a 32-ft diameter cone shaped canopy surfaced with chromium plated sheet copper and supported 50 ft above the fountain on 6 structural steel legs. The reflected light from this specular surface created an interesting mat of mobile color and added a warm glow to the court. A 25-hp motor directly connected to a centrifugal pump circulated 1,200 gal of water per minute through the fountain. The total connected lighting load was 42 kw.

The climaxing feature of the spectacular lighting was furnished by the battery of 24 36-in. arc searchlights spreading a fan of varicolored beams of light over the grounds, and the battery of 17 36-in. incandescent searchlights the beams of which, crossing above the "morning glory" fountain in the electric court, contrasted vividly with the blue of the gaseous tubes forming the cascades and with the warm tints of the fountain colors. The group of arc searchlights known as the scintillator were arranged on a 2-step platform, each light taking 125 amp at 110 volts dc and producing a beam candle power of 60 million or a total of 1,440 million for the 24 units. A trained corps of operators maneuvered the group of lights through fantastic forms and color changes and directed the beams on clouds of steam, smoke bombs, etc., to provide many weird and striking effects.

Each of the group of 17 36-in. incandescent searchlights were equipped with a 3-kw incandescent lamp and each was operated without attendants at a fixed position, the beams intersecting over the axis of the fountain and fanning out over the south lagoon.

Statistical data (Table I) relating to the lighting features of an exposition, while at times interesting for purposes of comparison, are of little value as a guide to the engineer confronted with the problem of lighting an exposition. To determine why this is so we have only to review past expositions and note their variance in architectural style, landscaping, and general character. It is an inherent and fundamental purpose of expositions to mark epochs of time; to show the advances in materials and methods. Consequently the engineer responsible for planning the lighting for an exposition must approach his problem with the purpose of the exposition in mind and intent upon supporting the style and effects contemplated by the architects. Originality and appropriateness should be the outstanding characteristic of lighting installations of this class and these arise from the circumstances surrounding individual expositions rather than from the records of those in the past.

Table I—General Data—A Century of Progress

Number of transformer vaults installed	45
Number of transformers installed (10 to 333 kva)	177
Total connected load (kva)	27,562
Exterior lighting load (kw) (exclusive of amusements)	2,750
Exterior lighting standards—approx	1,160
Incandescent lamps installed (10 to 3,000-watt)	130,000
Primary feeder cable (ft)	300,940
Secondary feeder cable (ft)	252,236
Building feeders (ft)	407,061
Distribution Cable—Roads & Path Lighting (ft)	152,760
No. 00 wire for general distribution (ft)	317,000
No. 12 wire for general distribution (ft)	2,625,000
Pump log for cable runs (ft)	263,000
Raceway for wire runs (ft)	138,000
Gaseous tubes installed (ft)	19,877
Power consumption, total 170 days (kw)	35,111,852
Average consumption per 24-hour day (kwhr)	206,540
Peak load (kw)	18,952
Average watts per sq ft interiors	3.77
Total water requirements per day (gal)	10,000,000
Projector type units purchased by Exposition Company	
200-watt floodlights	1,600
500/1,000-watt floodlights	1,000
24-in. incandescent searchlights	72
36-in. incandescent searchlights	18
36-in. arc searchlights	24
250 to 1,500-watt underwater floodlights	277
Total paid attendance	22,321,497
Average per day, 170 days	131,303
Total area of enclosed grounds (acres)	424
Average of lagoons in grounds (approx. acres)	80
Interior lighting fixtures	7,762
Illumination intensities, building walls and roadways (foot-candles)	0.1 to 9

Additional articles on the subject of illumination as applied at the "Century of Progress" exposition, together with discussion of same, will be found in the February 1934 Transactions of the Illuminating Engineering Society. They are entitled:

1. Illumination of A Century of Progress Expositon, Chicago, 1933. W. D'A. Ryan.
2. Unique Lighting at A Century of Progress. L. A. S. Wood and Charles J. Stahl.
3. Lighting Features of the Fair. J. L. Stair, W. V. C. Foulks and W. E. Folsom.
4. Century of Progress Exhibit Lighting. C. M. Cutler.

These papers give interesting details and amplification of the material here presented by Mr. Ryan at the request of the A.I.E.E. committee on production and application of light.

Courtesy General Electric

GENERAL VIEW TOWARD NORTHERLY ISLAND

[illegible]

TWELFTH-STREET ENTRANCE AND BRIDGE

Courtesy General Electric

ELECTRICAL BUILDING, AND RADIO AND COMMUNICATIONS BUILDING

Courtesy General Electric

HALL OF SOCIAL SCIENCE, AND RADIO AND COMMUNICATIONS BUILDING

Courtesy General Electric

ELECTRICAL GROUP, VIEWED FROM WEST SHORE OF SOUTH LAGOON

Courtesy General Electric

HALL OF SCIENCE, VIEWED FROM EAST SHORE OF SOUTH LAGOON

Courtesy General Electric

GENERAL MOTORS BUILDING

Courtesy General Electric

GENERAL EXHIBITS GROUP ON LEIF ERIKSEN DRIVE

Courtesy General Electric

THE TRAVEL AND TRANSPORT BUILDING

NORTH ENTRANCE TO THE HALL OF SCIENCE

Courtesy General Electric

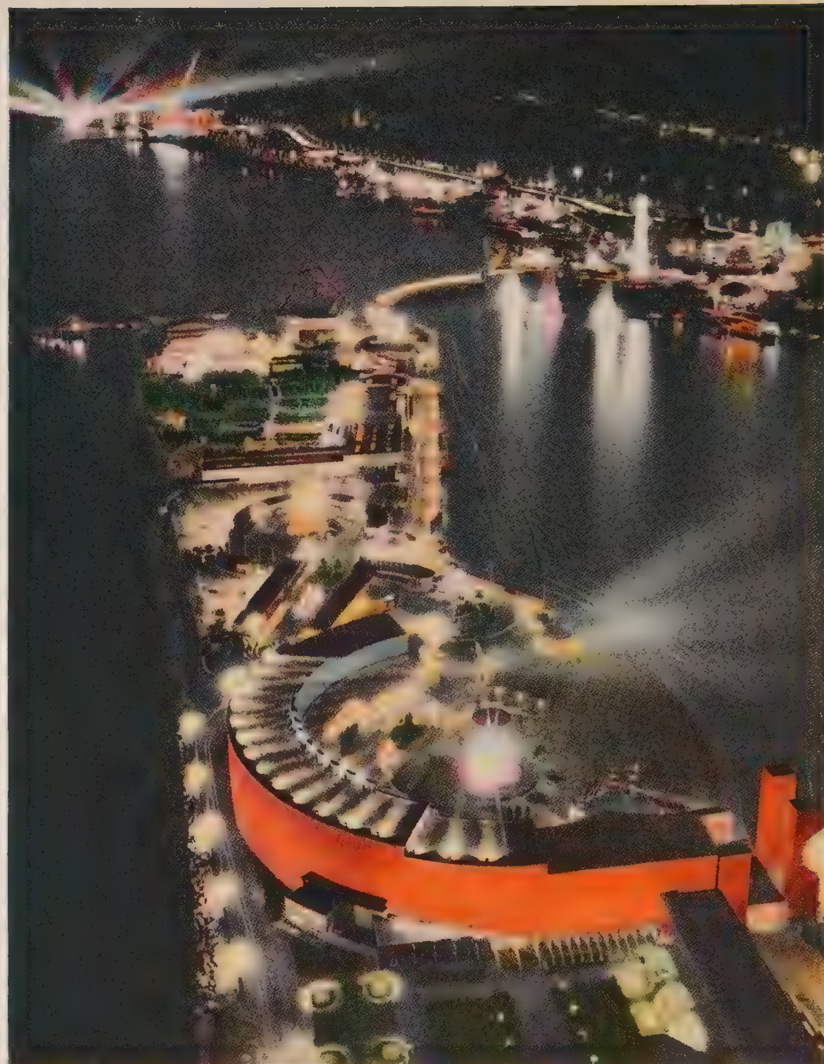
THE FEDERAL BUILDING

Courtesy General Electric

MERCURY-NEON PYLON IN COURT A OF THE GENERAL EXHIBITS GROUP

Courtesy General Electric

COURT OF THE ELECTRICAL BUILDING, "MORNING GLORY"
ELECTRIC FOUNTAIN IN FOREGROUND



Courtesy General Electric

NORTHERLY ISLAND FROM EAST SKYRIDE TOWER

Courtesy General Electric

SCINTILLATOR FAN, AS SEEN FROM THIRTY-FIRST-STREET ENTRANCE

Courtesy General Electric

VIEW LOOKING SOUTH FROM WEST SKYRIDE TOWER

Communication—Past and Present

By Bancroft Gherardi, President A.I.E.E. 1927–28

Pointing out that when the A.I.E.E. was founded in 1884 telegraphy was 40 years old and telephony 8 years old, the author traces briefly the significant developments and tremendous growth of electrical communication and the significance and importance of the parallel growth of the Institute. "Both grew out of the extension of our knowledge of certain laws of nature, and both were encouraged in their growth by the social and economic results that were possible from the application of electricity." The record of 50 years of communication development is traced through a half century of Institute publications.

WHEN in May 1884 a group of men, numbering perhaps a hundredth of our present membership, gathered together to found the American Institute of Electrical Engineers, none of them could foresee what the organization itself would grow to be or the future of the industries which would be founded on electrical knowledge. They were interested in the theory and the practical use of electricity. They must have believed that something well worth while would grow out of the application of electricity to the service of mankind, but the tremendous developments that would result from applying electricity to social and economic purposes were concealed then in the darkness of the future. I feel honored in being asked to perform the pleasant duty of recording at this time, when the Institute is completing the first 50 years of its life, what has happened in the communication art during that period.

From the earliest days until the invention of the telegraph, communication between persons at a distance was essentially a matter of transportation. Either a written message was transported by some one of the means then available or the messenger himself traveled, either on foot, on horseback, by stage coach, by boat, or by railroad. With some negligible exceptions used only for specialized purposes, communication was dependent upon transportation and subject to all its limitations. With the invention and development of the electric telegraph, communication by the written message first became independent of transportation. In the United States the first application was by Morse in 1844. Still, however, communication by the spoken word could not be carried on over distances of more than a few hundred feet and conveniently only over distances of a few feet. Alexander Graham Bell in 1876, by the invention of the telephone, offered the possibility of communication by the spoken word between people separated by considerable distances, so that it was no longer necessary for those desiring such communication to meet at a common point to make conversation possible.

When the Institute was founded, telegraphy was 40 years old. The telephone had been invented only 8 years. Radio-telegraphy and radio-telephony did not exist. From the first, a realization of the advantages to be derived from electrical communication led to the rapid development of both telegraphy and telephony. How much of this has taken place during the 50 years of the life of the American Institute of Electrical Engineers is briefly indicated by the following figures. During 1884, there were sent about 40 million telegraph messages in the United States. In 1929, the peak year, just prior to the depression, this figure had increased to 235 million messages. In 1884, there were 198 million telephone messages sent in the United States, and in the peak year 1930 the usage of the telephone had reached the stupendous total of 27,800 million messages. For several recent years the messages sent electrically have greatly exceeded in number the total of the first-class mail pieces in the United States.

It is not a mere coincidence that the life of the American Institute of Electrical Engineers has been paralleled by the tremendous growth of electrical communication. Both grew out of the extension of our knowledge of certain laws of nature, and both were encouraged in their growth by the social and economic results that were possible from the application of electricity.

The early development of the telegraph was closely associated with the railroads which had an urgent need for this form of communication, and telegraph lines were very generally built along the railroad routes. The wires were generally of iron; hard drawn copper was not invented until 1877, and cable development did not start until about the beginning of our 50-year period. Many of the present forms of telegraph circuit had been worked out, including duplex and quadruplex and Baudot's multiplex and printing telegraph, although this form was not applied in this country until a later date. Harmonic telegraphs which foreshadowed our modern carrier telegraph developments had been worked upon by inventors, including Alexander Graham Bell, for a decade or more, and Gray's harmonic telegraph had been given a trial. Following the first temporary success in 1858, permanent transatlantic telegraph

service by cable was established in 1866. One of my valued possessions is a medal presented by the New York Chamber of Commerce to my father for his part in the early cable laying expedition, as an officer of the U.S. Frigate Niagara.

Fire alarm and burglar alarm systems were well developed and police alarm systems were just coming into general use. Stock quotation systems had been established. Railway signaling systems had been invented, but only one railroad in the United States was equipped throughout its entire length with automatic electric block signals. An editorial in the September 1884 issue of the "Electrician and Electrical Engineer" refers to the adoption of automatic signals as the most important step to be taken in the direction of perfecting our modern railway systems.

In 1884 telephony was still very young. There had been sufficient technical development to produce the fundamentals of a telephone exchange system in early crude form. Early types of the carbon transmitter had been invented and placed in service. The first switchboards had been constructed, and the first multiple board was placed in service in Chicago in 1879. The use of the metallic circuit telephone system had just begun. A beginning had been made in the development of telephone wires in cable and, as already noted, hard drawn copper had just been invented. Long distance telephony was beginning, a line from Boston to Providence having been established in 1881. The first conversation between New York and Boston using hard drawn copper circuits took place in 1884, the year of the founding of the Institute.

It is difficult within the scope of a brief statement to indicate adequately the extraordinary development of the technique of electrical communication that has taken place during the past 50 years, building upon the fundamental technical principles that had been established by 1884 and applying many new technical principles discovered since.

The hand sending method of operating telegraph circuits has been largely displaced by the application of the printing telegraph. Although the idea of having telegraph impulses print the message is as old as telegraphy itself, the present successful forms of apparatus are of modern development representing the culmination of many decades of intensive effort and the creation of successively better forms of this apparatus[10] (references are by number to items in bibliography). The types now in general use were all developed within the last 20 years.[36,41] The scope of practical application of printing telegraph apparatus has been extended by a new method for maintaining synchronism or more exactly isochronism between the machines on the same circuit by the so-called start-stop principle which is utilized in most of the printing telegraph machines now in operation.[41]

Telegraph circuits, where not in cable, are now largely built of hard drawn copper, only about 10 per cent of the telegraph circuit mileage still making use of iron. There has been a great extension in the use of telegraph circuits in cable, a third of the telegraph circuit mileage of the country now being of that type. This use of telegraph in cables has largely come about through the development of successful carrier telegraph systems, realizing at la[st] the dream of the early telegraph workers that a large number of telegraph circuits could be provide[d] on one pair of wires.[38,55] An important requireme[nt] for the success of this development was the applic[a]tion of electrical means for separating the channel[s] whereas the early inventors necessarily tried to u[se] mechanical means.[5] The carrier telegraph art al[so] depends upon the vacuum tube, itself a developme[nt] of the last 20 years.[1,15]

Many advances were made in the operation [of] long submarine telegraph cables through loading a[nd] other improvements by means of which the messa[ge] capacity of these cables was increased sever[al] fold.[56,85]

A striking technical development of this period [is] radio, first applied to telegraphy. Although is[o]lated experiments, which were early experiments [in] radiation, date back to 1842 with Joseph Henry['s] detection of Leyden jar disturbances at distanc[es] of several hundred feet and lightning discharges [at] distances of 20 miles and while in 1864 Maxwe[ll] advanced his electromagnetic theory which showe[d] radio communication to be possible, the birth [of] radio science is generally associated with Hert[z's] brilliant work in 1887 and the beginning of practic[al] application came with the work of Marconi [in] 1896.[6,9,11] From then the development of radi[o] telegraphy was rapid, transatlantic service bei[ng] established in 1908 and ships being general[ly] equipped with this valuable means of promoti[ng] safety by the year 1913.[19,30,34,93]

Although in 1884 that then novel and primiti[ve] device, the telephone, had already been put to wor[k] there being about 150,000 in use in the Unite[d] States, the technical development of telepho[ne] systems had only started. This development h[as] included 3 major groups of problems: (1) apparat[us] at each telephone station to convert sound energ[y] into electrical waves and back again and to provi[de] signals to attract the attention of users; (2) switc[h]ing systems at central points for rapidly and acc[u]rately connecting together any 2 telephones th[at] might desire to communicate with each other; an[d] (3) means for transmitting the telephonic curren[t] over distances little or great without excessive lo[ss] or other modification.

Shortly after the Institute was founded came t[he] first successful granular carbon telephone tran[s]mitter, so great an improvement over the earli[er] forms of transmitter that, by many modificatio[ns] and improvements, it has become, without changin[g] its essential principle, the highly developed telepho[ne] transmitter of today. At about the same time ca[me] Carty's invention of the bridging principle to repla[ce] for telephone circuits the series types of connectio[n] inherited from the telegraph practice.[12] One of i[ts] many useful applications was to the signal bells [at] telephone stations, resulting in a great improveme[nt] in performance. The hand set type of arrangemen[t] while suggested early in this epoch and used in [a] limited way, presented serious technical difficulti[es] which, for the severe requirements for service in t[he] United States, were overcome only in recent years.[8...]

Telephone switchboards of the early forms were relatively crude. In the period 1886–1894, the common battery switchboard was invented and introduced into practical use. Through successive improvements, the capacity of the common-battery switchboard was raised from a few hundred lines in the early models to 9,000 lines by the year 1902.[12] Throughout the development of switching systems there was a trend toward the greater use of automatic devices, culminating in the development of the machine switching systems in which, for certain types of calls, the switching is entirely mechanical. The first successful step-by-step machine switching system was placed in service in 1892. The panel machine switching system designed to meet the complex conditions of metropolitan areas was first placed in service in 1915. Today dial system switching has been provided for 40 per cent of the telephones of the country.[18,21,26,27,35,43,73,83]

The transmission of telephone currents over long distances has been almost wholly a development of this era. The first New York-Boston telephone circuit in 1884 using hard drawn copper led to the use of copper for other interurban lines and the development of the first transposition system to prevent interference between numbers of telephone circuits carried on the same pole lines.[4,13,31] Phantom circuits to give 3 independent circuits on 2 pairs of wires were experimented on in 1884, but were not successful until about 1902. In 1899 came Pupin's invention of loading, by which means the transmission efficiency of telephone wires was increased. Loading not only permitted the extension of open-wire circuits to greater distances, but it also made possible long distance telephone transmission over cable circuits.[8,24,60] From small beginnings in 1902, when 49 pairs of a 10-mile cable from New York to Newark were loaded for commercial service, the use of this invention has extended until at the present time there are about 8,500,000 coils in use in the United States. Cables for phantom circuit working were made successful in 1910.

Another great technical step in making possible the extension of long distance telephony was the development of the telephone repeater. The first commercial application of repeaters was in 1904 between New York and Chicago. These were of the mechanical type, the vacuum tube repeater being first used commercially in 1913.[32] The combined effect of these advances in the art led to the opening of transcontinental service in 1915 and the rapid extension of the service toward the ideal of a universal service between all points of the country.[64,78] These developments made possible the use of extensive long distance telephone cable systems, including circuits in cable 2,000 miles or more in length. In this way it was possible to connect together, by means of storm-proof plant, many of the larger cities in the country.[10,46,64]

Carrier telephone systems, by which several independent telephone channels are simultaneously carried on one pair of open wires, marked another step in long distance transmission. They were first applied commercially in 1918 between Baltimore and Pittsburgh.[38,68,76] There are 575,000 miles of carrier circuit in the telephone plant today. Now, through a further series of technical developments, we face the prospect of having in the future carrier telephone methods applied to the toll cable plant giving a still more effective use of the pairs in telephone toll cables.[96]

In 1921 the telephone network, which theretofore had been confined to the continental area of the United States and Canada, began to stretch out to other countries. The first step was the establishment of service between the United States and Cuba through the placing of submarine telephone cables of novel design.[39] In 1915 the first experimental transatlantic telephone communications using radiotelephone links were held, and in 1927 commercial transatlantic service was established.[33,44,69,80] This form of development has expanded so rapidly that today there are a quarter-million miles of intercontinental radiotelephone circuits in service in the world, and it is possible from any telephone in the United States to reach 92 per cent of all the telephones in the world, located in 54 different countries on all the continents of the globe. In the last few years telephone service has been extended to ships at sea by the use of radio, 19 ships being equipped at the present time for connection to the American telephone system.[79] By the application of newly developed materials and an advanced technique, it will be possible to build a transatlantic telephone cable when the continued increase in messages to be handled makes this desirable.

With the rapid development of telephone networks throughout the country, their use for the transmission of music and for other entertainment purposes has been in the minds of the experts. In the early days, however, such transmissions, while interesting scientific demonstrations and well received, did not represent a reproduction of music or even of voices which was technically faithful. With the perfection of the telephone art it became possible to carry out such transmission with increasingly good reproduction, and beginning with about 1915 there was a large development of such service using loud speakers to bring the programs to audiences.[47,49,53,70] The latest step in perfecting the electrical transmission of music, in which the transmission is not only of extreme fidelity but includes the effects of acoustic perspective and also a range of volumes far beyond that which can be produced directly by an orchestra, has just recently been described and demonstrated before this Institute.[97]

Improvements in radiotelephony led to the introduction, in 1920, of radio broadcasting of programs. This has grown to its present large proportions with about 600 radio transmitting stations broadcasting programs to 16 million radio receiving sets in this country.[48,49,53,58,62,66,70] Many of these transmitting stations are linked together in groups by program transmission wire networks, aggregating about 35,000 miles of circuit.[77]

The application of the technique developed for electrical communication has led naturally to its extension to uses other than those contemplated in the original telephone and telegraph systems.[25,37] Private wire telegraph systems have developed a

Some Contrasts

Above Modern dial type and telephone

(Right) Desk stand telephone of 1886. Equipped with "long-distance" transmitter and with exposed transmitter wiring and switch-hook contacts

(Below) View of Harrisburg-Pittsburgh cable route, the 2 cables shown providing more than 1,000 telephone wires

Interior of Chicago manhole containing some 18,000 exchange plant wires, 3,500 toll wires, and 3,200 loading coils

Section of latest type exchange plant cable containing 18 groups of 101 pairs of wire each (total of 3,636 wires) in lead sheath of $2^5/_8$-in. diameter

Pole line erected in New York City in 1887, consisting of 90-ft poles carrying 25 to 30 crossarms (250 to 300 wires)

Central office roof structure (Boston) of 1883 terminating 2,400 wires

in Communication Equipment

Stock quotation transmitting center, New York 1881

Telegraph operating room, New York 1881, showing women sending and receiving telegrams by the key and sounder method

Modern transmitting center for nation-wide stock quotation service with high-speed tickers

Modern telegraph operating room, New York, showing multiplex telegraph equipment with associated sending keyboards and receiving printers

wide variety of uses, including automatic stock quotation boards and the transmission of weather maps for air navigation.[86,90] The last few years have witnessed the extension of application of electrical communication to assist the law enforcing agencies, including teletypewriter systems between the police offices and radiotelephone for continuous contact with police automobiles.[86] Radio communication has been adapted extensively to the assistance of navigation, both of ships and of aircraft, through the development of methods for direction finding, radio beacons, and similar purposes.[74,75,81,90,95] There has been a rapid extension of remote control and of the transmission of information for a great variety of uses, the remote control of switches in power systems and remote indications of switch positions and of loads and remote indications of water levels.[91,92]

A recent, and in one sense ambitious, development of electrical communication is television. The eye conveys much more information to the observer than the ear, receiving electromagnetic impulses very much more complicated in structure than the acoustic impulses received in hearing. This is illustrated by the fact that in the electrical transmission of photographs over telephone circuits from 5 to 15 minutes is required for the transmission of a photograph, whereas television is equivalent to transmitting at least 16 photographs per second. The very large number of electromagnetic impulses that must be transmitted in a second, or to express it another way, the wide band of frequencies required for the transmission of television signals, raises difficult problems both in the design of the terminal equipment and with reference to the transmitting medium, whether wire or radio. Successful demonstrations of television over a distance of 250 miles were made in 1927, and technical development, hoping for ultimate commercial application, is actively continuing.[65]

The records of the Institute's proceedings are a valuable library of these tremendous technical advances of the past 50 years. This is illustrated by an appended bibliography of selected references from the Institute publications in which are set forth technical discussions of these important developments and to which reference has been made throughout this review. Although no general discussion of these papers is possible within the limits of this article, it is of interest to note in passing the first paper in the Institute's TRANSACTIONS. This was presented at the first technical meeting in October 1884, by Professor Houston and was entitled "Notes on Phenomena in Incandescent Lamps." It discusses the "Edison effect," that is, the discovery that in an evacuated bulb an electric current would flow in one direction between a hot filament and cold cathode, but not in the other direction. This all will now recognize as the first 2-element vacuum tube and the basis of the modern science of electronics which was stimulated 20 years later by De Forest's addition of a third element and the development by many workers of the great possibilities which such a 3-element tube possesses. It is, indeed, interesting and significant that the first Institute paper should be on a subject of such fundamental importance, one on which a large number of the outstanding developments of electrical communication of the past 20 years depend and which today is engaging to an increasing extent the attention of men in the electrical power field as well as in the field of electrical communication.

As a result of the extension of the electrical transmission of the spoken and the written word, in the United States today, where many of the fundamental concepts originated and much of the technical development was done, it is no exaggeration to say that we can have almost instantaneous communication between any 2 parts of our country. While these developments have been most extensively applied in the United States, a somewhat similar statement may be made as to the scope of electrical communication in other industrial countries. In addition, extending between the various nations there is a well developed electrical communication system.

Communication is today an integral part of our social and economic life. That the American Institute of Electrical Engineers has contributed in a substantial way to the accomplishment of these results cannot be doubted. Among the leaders in that organization from time to time have been Alexander Graham Bell, Michael I. Pupin, John J. Carty, Norvin Green, Frank B. Jewett, and Harry P. Charlesworth, each of whom served as its President. These same men likewise have been leaders in the communication development of which we are speaking. They are but a few of the thousands connected with the communication industry who have been members of the American Institute of Electrical Engineers. Through its proceedings and through the informal contacts with others made possible by its meetings, all of these men have derived some of the knowledge and some of the inspiration necessary for the successful accomplishment of the communication enterprises, built up as they are upon complicated technical working.

As the fiftieth year of the life of our Institute draws near to its end, we look back with satisfaction upon the results of the application of electricity to the welfare of mankind. We surely are warranted in believing that if we could look forward into the years to come we would there see still other and equally extraordinary developments, perhaps more extraordinary developments, which still lie before us and which will minister to the comfort and convenience of the people of the United States and of the world. In these developments the members of of the American Institute of Electrical Engineers, present and future, will play a distinguished part.

Bibliography of Selected Communication References From Institute Publications

1. NOTES ON PHENOMENA IN INCANDESCENT LAMPS, Edwin J. Houston. v. 1, 1884.

2. SYNCHRONISM, Edwin J. Houston. v. 1, 1884.

3. RECENT IMPROVEMENTS IN APPARATUS FOR OCEAN CABLING, Charles Cuttriss. v. 5, 1888.

4. Inductive Disturbances in Telephone Circuits, J. J. Carty. v. 8, 1891.

5. Practical Aspects of Low Frequency Electrical Resonance, M. I. Pupin. v. 10, 1893.

6. Exhibition of Marconi Wireless Telegraph Apparatus. v. 14, 1897.

7. Historical Sketch of the Fire Alarm Telegraph, Adam Bosch. v. 14, 1897.

8. Propagation of Long Electrical Waves, M. I. Pupin. v. 16, 1899.

9. The Possibilities of Wireless Telegraphy—A Topical Discussion. v. 16, 1899.

10. A New Page Printing Telegraph, William B. Vansize. v. 18, 1901.

11. Speeches at Institute Dinner in Honor of Guglielmo Marconi, v. 19, 1902.

12. The Evolution of the Telephone Switchboard, Thomas D. Lockwood. v. 21, 1903.

13. Transposition and Relative Location of Power and Telephone Wires, P. W. Lincoln. v. 21, 1903.

14. The Telautograph, James Dixon. v. 23, 1904.

15. The Audion, Lee De Forest. v. 25, 1906.

16. Track-Circuit Signaling on Electrified Roads, L. Frederick Howard. v. 26, 1907.

17. Wireless Telephony, R. A. Fessenden. v. 27, 1908.

18. A Study of Multi-Office Automatic Switchboard Telephone Systems, W. Lee Campbell. v. 27, 1908.

19. Alternator for One Hundred Thousand Cycles, E. F. W. Alexanderson. v. 28, 1909.

20. The Modern Telephone Cable, Frank B. Jewett. v. 28, 1909.

21. A Modern Automatic Telephone Apparatus, W. Lee Campbell. v. 29, 1910.

22. American Telegraph Engineering—Notes on History and Practice, William Maver, Jr., and Donald McNicol. v. 29, 1910.

23. Telegraph Transmission, Frank F. Fowle. v. 30, 1911.

24. The Commercial Loading of Telephone Circuits in the Bell System, Bancroft Gherardi. v. 30, 1911.

25. Some Recent Developments in Railway Telephony, Gregory Brown. v. 30, 1911.

26. The Semi-Automatic Method of Handling Telephone Traffic, Edward E. Clement. v. 30, 1911.

27. Automatic Private Branch Exchange Development in San Francisco, Gerald Deakin. v. 31, 1912.

28. Report by the Joint Committee on Inductive Interferences to the Railroad Commission of the State of California. v. 33, 1914.

29. Recent Results Obtained From the Preservative Treatment of Telephone Poles, F. L. Rhodes and R. F. Hosford. v. 34, 1915.

30. Continuous Waves in Long Distance Radio Telegraphy, L. F. Fuller. v. 34, 1915.

31. The Design of Transpositions for Parallel Power and Telephone Circuits, H. S. Osborne. v. 37, 1918.

32. Telephone Repeaters, Bancroft Gherardi and Frank B. Jewett. v. 38, 1919.

33. Radio Telephony, E. B. Craft and E. H. Colpitts. v. 38, 1919.

34. Transoceanic Radio Communication, E. F. W. Alexanderson. v. 38, 1919.

35. Applicability of Automatic Switching to All Classes of Telephone Service, A. B. Smith. v. 38, 1919.

36. Printing Telegraph Systems, John H. Bell. v. 39, 1920.

37. Some Phases of Railroad Telegraph and Telephone Engineering, Stanley Rhoads. v. 40, 1921.

38. Carrier Current Telephony and Telegraphy, E. H. Colpitts and O. B. Blackwell. v. 40, 1921.

39. Key West—Havana Submarine Telephone Cable System, W. H. Martin, G. A. Anderegg, and B. W. Kendall. v. 41, 1922.

40. Philadelphia-Pittsburgh Section of the New York-Chicago Cable, J. J. Pilliod. v. 41, 1922.

41. Printing Telegraph Systems Applied to Message Traffic Handling, A. H. Reiber. v. 41, 1922.

42. Radio Telegraphy, Guglielmo Marconi. v. 41 (*Jl.*), 1922.

43. Machine Switching Telephone System for Large Metropolitan Areas, E. B. Craft, L. F. Morehouse, and H. P. Charlesworth. v. 42, 1923.

44. Transatlantic Radio Telephony, H. D. Arnold and Lloyd Espenchied. v. 42, 1923.

45. The Wave Antenna—A New Type of Highly Directive Antenna, H. H. Beverage, C. W. Rice, and E. W. Kellogg. v. 42, 1923.

46. Telephone Transmission Over Long Cable Circuits, A. B. Clark. v. 42, 1923.

47. Public Address System, I. W. Green and J. P. Maxfield. v. 42, 1923.

48. Electrical Loud Speakers, A. Nyman. v. 42, 1923.

49. High Quality Transmission and Reproduction of Speech and Music, W. H. Martin and H. Fletcher. v. 43, 1924.

50. Measuring Methods for Maintaining the Transmission Efficiency of Telephone Circuits, F. H. Best. v. 43, 1924.

51. Practices in Telephone Transmission Maintenance Work, W. H. Harden. v. 43, 1924.

52. Transmission Unit and Telephone Transmission Reference Systems, W. H. Martin. v. 43, 1924.

53. The Function and Design of Horns for Loud Speakers, C. R. Hanna and J. Slepian. v. 43, 1924.

54. Echo Suppressors for Long Telephone Circuits, A. B. Clark and R. C. Mathes. v. 44, 1925.

55. Voice-Frequency Carrier Telegraph System for Cables, B. P. Hamilton, N. Nyquist, M. B. Long, and W. A. Phelps. v. 44, 1925.

56. The Loaded Submarine Telegraph Cable, Oliver E. Buckley. v. 44, 1925.

57. Metallic Polar-Duplex Telegraph System for Long Small-Gauge Cables, J. H. Bell, R. B. Shanck, and D. E. Branson. v. 44, 1925.

58. Notes on the Development of a New Type of Hornless Loud Speaker, Chester W. Rice and Edward W. Kellogg. v. 44, 1925.

59. Design of Non-Distorting Power Amplifiers, E. W. Kellogg. v. 44, 1925.

60. Development and Application of Loading for Telephone Circuits, Thomas Shaw and William Fondiller. v. 45, 1926.

61. Methods of High Quality Recording and Reproduction of Music and Speech Based on Telephone Research, J. P. Maxfield and H. C. Harrison. v. 45, 1926.

62. Radio Broadcast Coverage of City Areas, Lloyd Espenchied. v. 45, 1926.

63. Refraction of Short Radio Waves, William G. Baker and Chester W. Rice. v. 45, 1926.

64. Transmission Features of Transcontinental Telephony, H. H. Nance and O. B. Jacobs. v. 45, 1926.

65. Symposium on Television. v. 46, 1927.

66. Quantitative Determination of Radio Receiver Performance, H. D. Oakley. v. 46, 1927.

67. A New Electronic Rectifier, L. O. Grondahl and P. H. Geiger. v. 46, 1927.

68. Carrier Systems on Long Distance Telephone Lines, H. A. Affel, C. S. Demarest, and C. W. Green. v. 47, 1928.

69. Transatlantic Telephone Service, K. W. Waterson and O. B. Blackwell. v. 47 (*Jl.*), 1928.

70. Loudspeakers of High Efficiency and Load Capacity, C. R. Hanna. v. 47, 1928.

71. Certain Topics in Telegraph Transmission Theory, H. Nyquist. v. 47, 1928.

72. The Planning of Telephone Exchange Plants, W. B. Stephenson. v. 47, 1928.

73. Tandem System of Handling Short-Haul Toll Calls, F. D. Wheelock and E. Jacobsen. v. 47, 1928.

74. Electrical Aids to Navigation, Robert H. Marriott. v. 48, 1929.

75. Uses of Radio as an Aid to Air Navigation, J. H. Dellinger. v. 48, 1929.

76. Carrier Telephone System for Short Toll Circuits, H. S. Black, M. L. Almquist, and L. M. Ilgenfritz. v. 48, 1929.

77. Long Distance Cable Circuit for Program Transmission, A. B. Clark and C. W. Green. v. 49, 1930.

78. A General Switching Plan for Telephone Toll Service, H. S. Osborne. v. 49, 1930.

79. Radio Telephone Service to Ships at Sea, William Wilson and Lloyd Espenchied. v. 49, 1930.

80. Symposium on Transatlantic Telephone Service. v. 49, 1930.

81. Air Transport Communication, R. L. Jones and F. M. Ryan. v. 49, 1930.

82. The Electrical Engineering of Sound Picture Systems, K. F. Morgan and T. E. Shea. v. 49, 1930.

83. Dial Telephone System Serving Small Communities of Southern California, F. O. Wheelock. v. 49, 1930.

84. Symposium on Coördination of Power and Telephone Plant. v. 50, 1931.

85. The Newfoundland-Azores High Speed Duplex Cable, J. W. Milnor and G. A. Randall. v. 50, 1931.

86. Modern Practices in Private Wire Telegraph Service, R. E. Pierce. v. 50, 1931.

87. The Time Factor in Telephone Transmission, O. B. Blackwell. v. 51, 1932.

88. Vertically Cut Sound Records—Recent Fundamental Advances in Recording and Reproducing Sound Using Vertical Undulations on a Disk, H. A. Frederick and H. C. Harrison. v. 51, 1932.

89. Telephone Handset—A Product of Research, W. C. Jones and A. H. Inglis. v. 51 (Elec. Engg.), 1932.

90. Wire Communication Aids to Air Transportation, H. H. Nance. v. 51, 1932.

91. Report on Telemetering, Supervisory Control and Associated Communication Circuits. v. 51 (Elec. Engg.), 1932.

92. Symposium on Traffic Signaling Systems. v. 51, 1932.

93. Radio Plant of R. C. A. Communications Inc., H. H. Beverage, C. W. Hansell, and H. O. Peterson. v. 52, 1933.

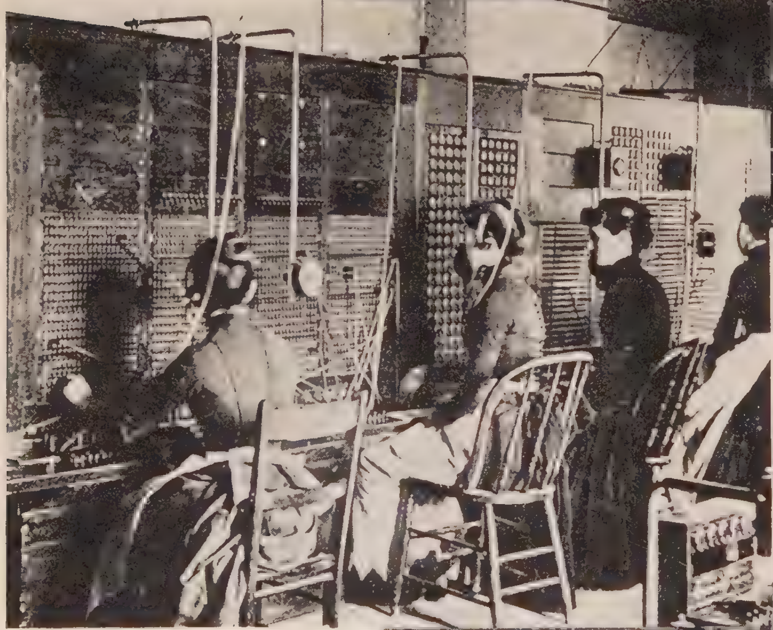
94. Symposium on Railroad Communication and Signaling. v. 52, 1933.

95. Radio Aids to Air Navigation, C. F. Green and H. I. Becker. v. 52, 1933.

96. Carrier in Cable, A. B. Clark and B. W. Kendall. v. 52, 1933.

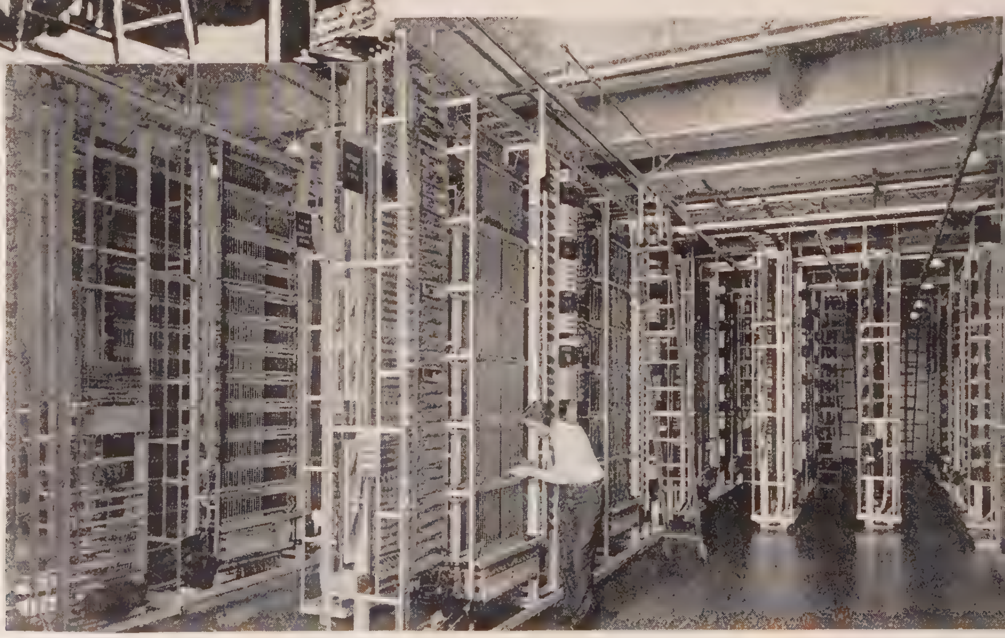
97. Symposium on Auditory Perspective. v. 53 (Elec. Engg.), 1934.

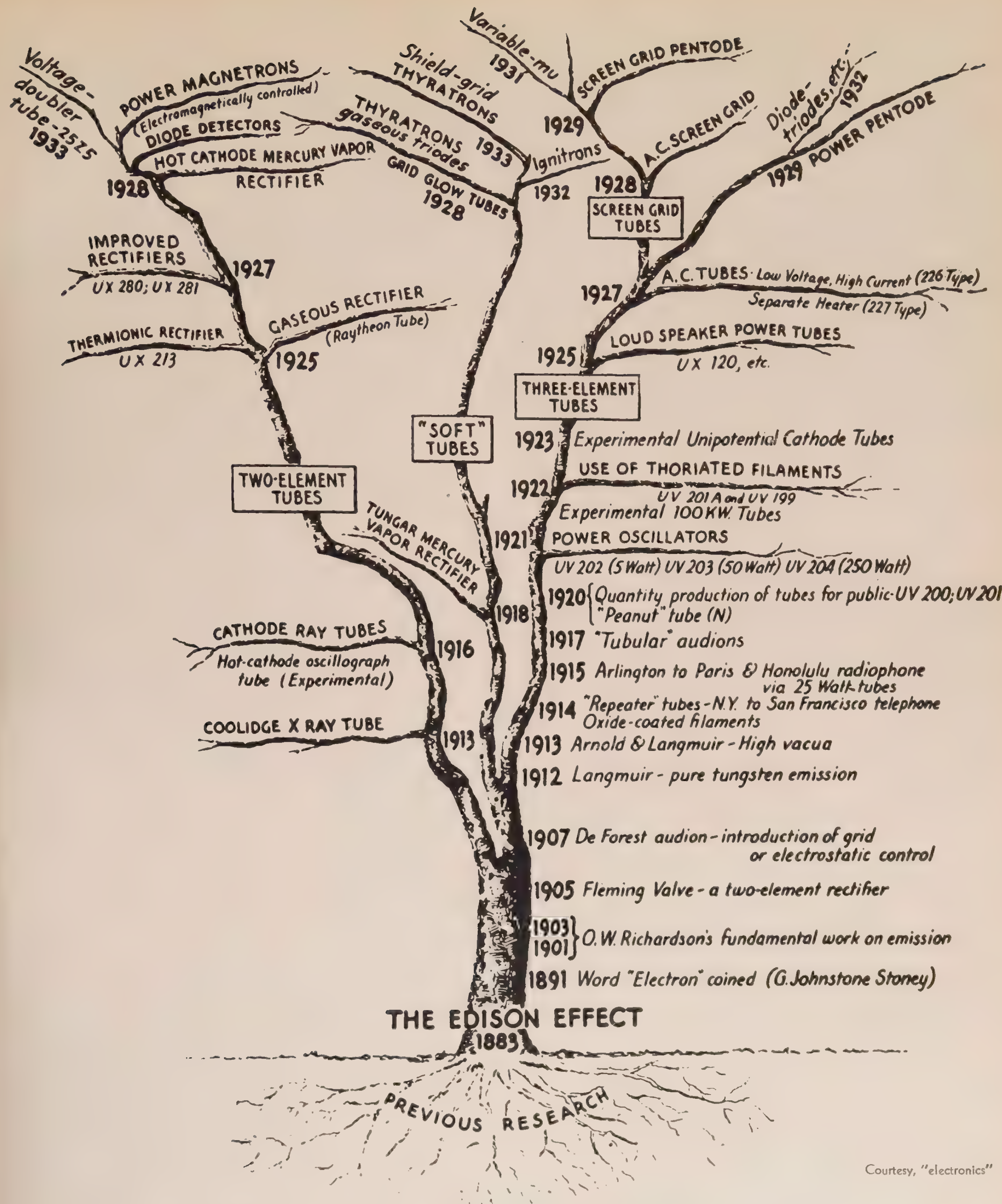
A modern manual subscriber switchboard of 1922. A portion of one of 160 switching units in New York City (including both manual and dial system offices) of types designed for a capacity of about 10,000 lines each



Milwaukee central office of 1883 serving about 700 lines covering the entire city. Switchboard equipped with annunciator type line signals

View of panel central office switchroom of Oakland, Calif., now in service. Typical selector frames of the panel type which perform the functions carried out by operators in manual switchboards. Picture shows a small portion of apparatus for one 10,000-line unit





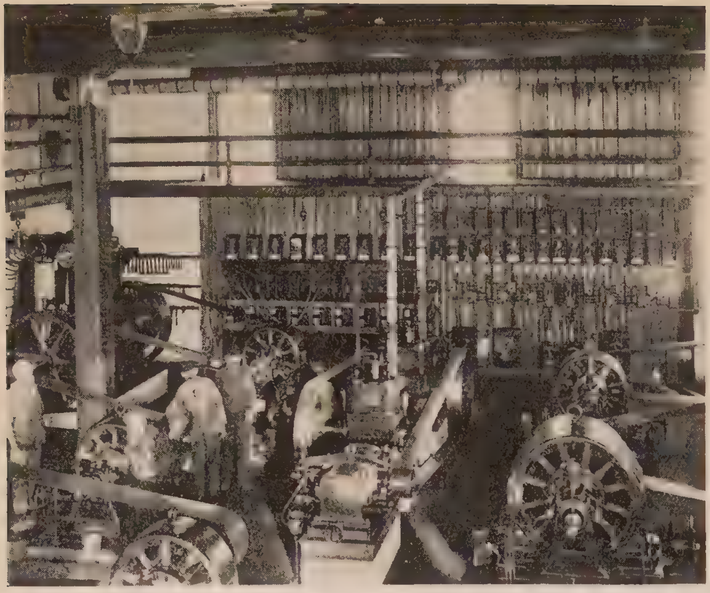
Courtesy, "electronics"

The Family Tree of the Thermionic Tube

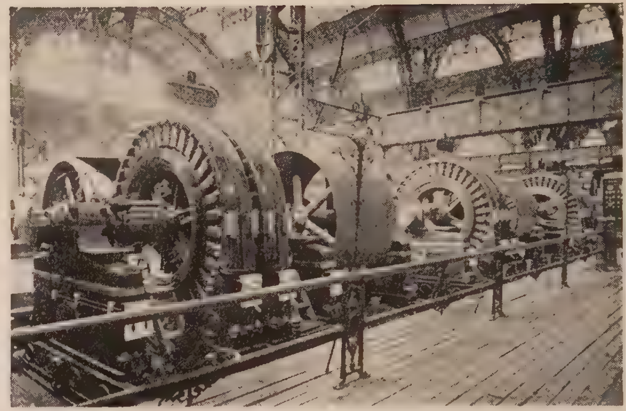
Public attention has generally overlooked that contribution of Mr. Edison's which seems destined to have the greatest influence on the world of the future. This was Edison's discovery in 1883 of the feeble flow of electrons in vacuo coming from the heated filament of his early incandescent lamps—the "Edison Effect." It is interesting to note that this phenomenon was discussed in the first paper presented at the first technical session of the A.I.E.E., held in Philadelphia, October 1884. (The first page of this paper is reproduced on p. 654 of this issue.)

For 20 years this pregnant phenomenon lay unused by the world, until in the early 1900's it formed the foundation for the first electronic tubes which now, in a myriad of forms, have given us radio, broadcasting, long-distance telephony, short waves, sound pictures, television, power control, rectification, electric surgery, electronic music, and a host of other developments. Thus the "Edison Effect" is bound to be increasingly recognized as the most epochal discovery in all the inventor's eventful career.

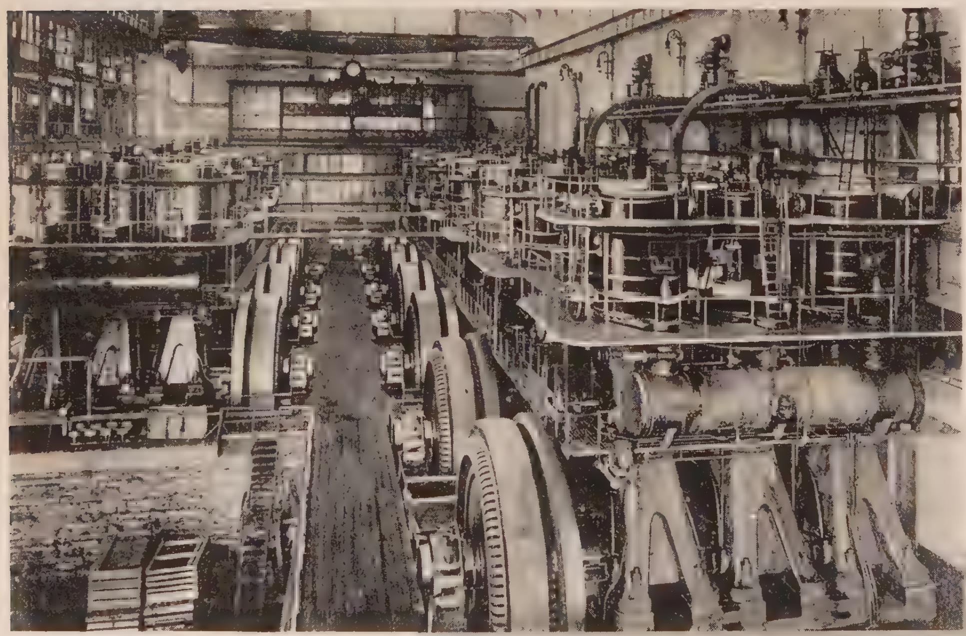
Some Steam-Electr



Early alternating current power plants had several small belt-driven alternators. This is an a-c plant of about 1886; note the wood panel switchboard and the early type meters mounted on it
(Westinghouse photo)

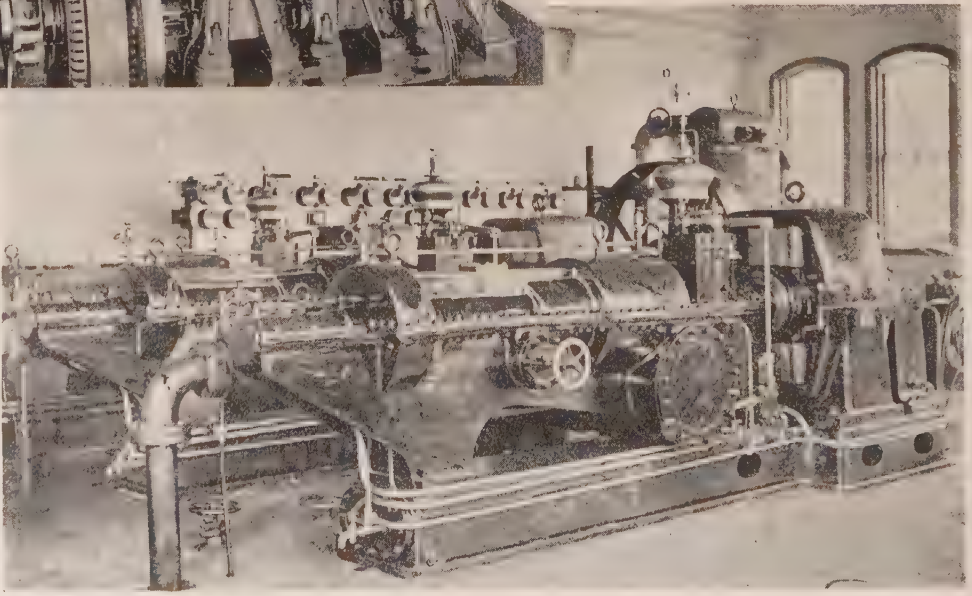


(Above) Three of the 12 1,000-hp 2,200-volt 2-phase generators that supplied power for the Chicago World's Fair of 1893. Each 2-phase unit consisted of 2 single-phase generators on the same shaft. This was the most powerful plant built up to that time and the machines were then the largest a-c machines in America
(Westinghouse photo)

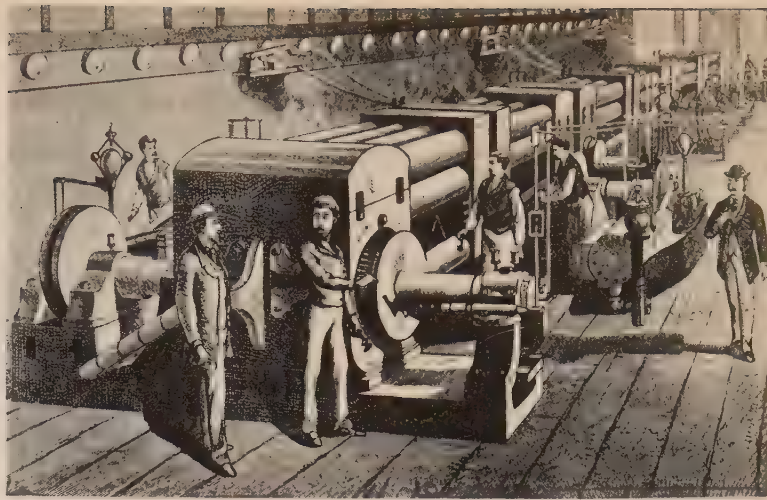


(Above) Waterside No. 1 station, first a-c generating station of the New York (N. Y.) Edison Company, as it appeared in 1904 after the first 11 3,500-kw units had been installed. The huge cross-compound engines overshadowed the generators they drove. All these machines have been removed, the last 7 having been replaced by 2 35,000-kw turbine-generator units prior to 1919. Originally designed for a total capacity of 56,000 kw, the plant now has an installed capacity of 214,000 kw in the same area
(Consolidated Gas Co. photo)

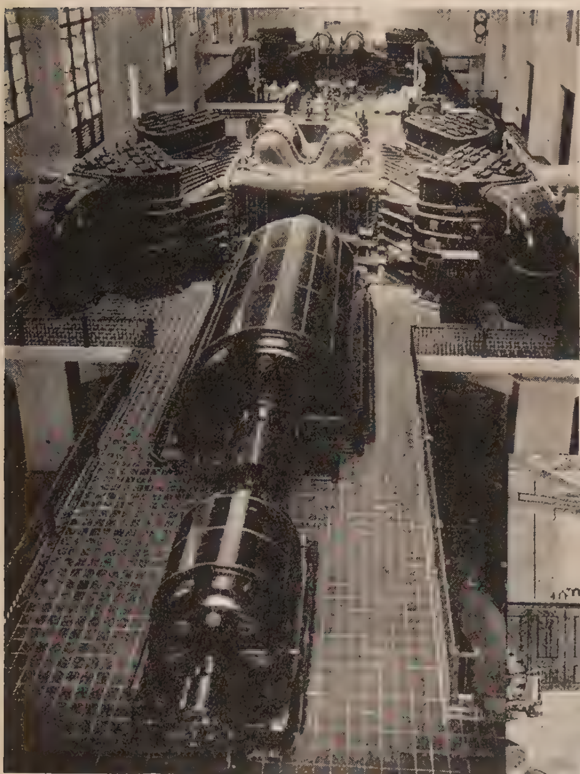
(Below) Three 400-kw a-c steam turbine generating units installed in 1899 at the plant of the Westinghouse Air Brake Company, Wilmerding, Pa., the first important steam turbine installation in America. These turbines drove 400-kw 3,600-rpm revolving-armature 440-volt bipolar 60-cycle generators. The plant operated at 125 lb per sq in. steam pressure and had a fuel consumption of 22 lb per kwhr
(Westinghouse photo)



Generating Stations

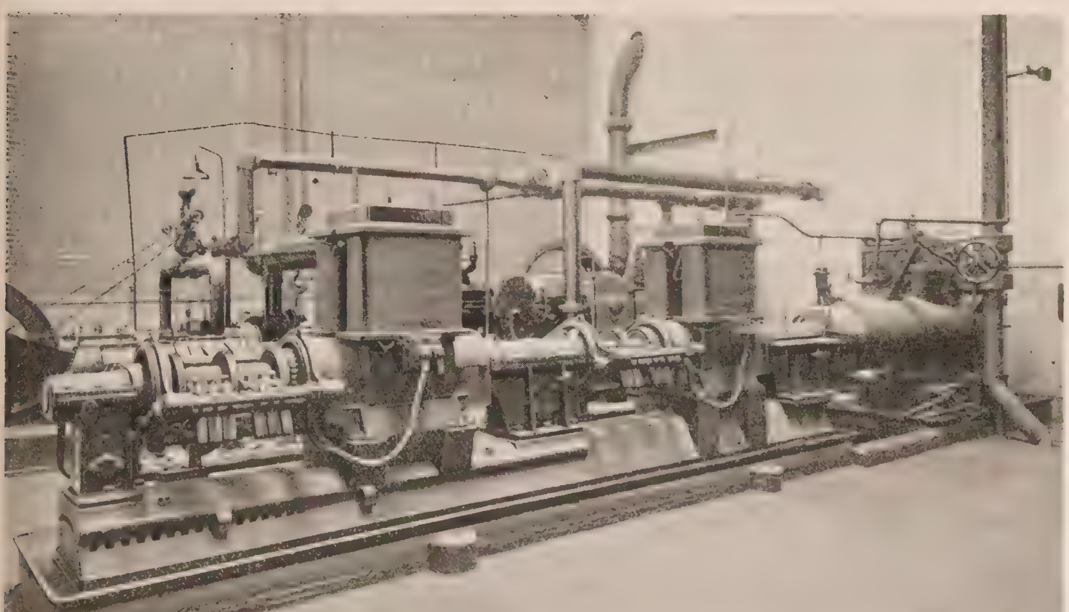


Dynamo room of the original electric "central station," Edison's famous Pearl Street station in New York City, which began commercial operation September 4, 1882. All except one of these machines, which is now in the Ford Museum at Dearborn, Mich., were ruined by fire in 1890; they were dubbed "jumbos" because of their huge size, a complete machine weighing more than 60,000 lb
(Consolidated Gas Co. photo)



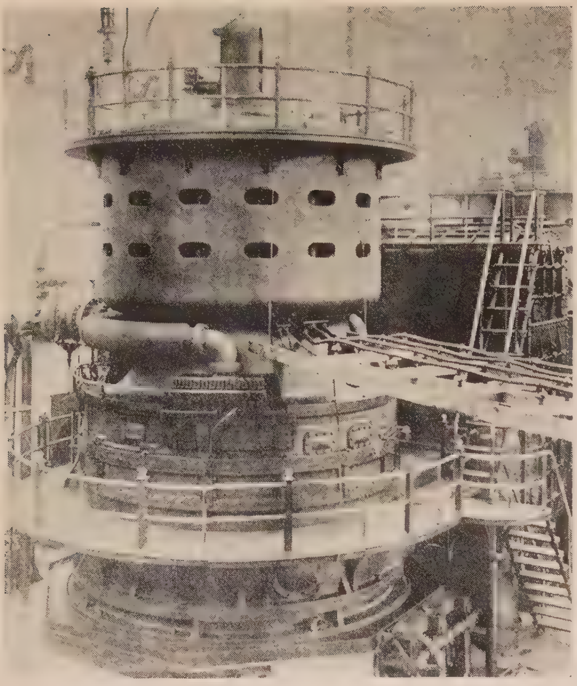
A modern counterpart of the early steam turbine stations shown on this and the facing pages, the Long Beach (Calif.) No. 3 station showing 2 94,000-kw tandem-compound units installed in 1928
(So. Calif. Edison Co. photo)

(Above) Brush central station in Philadelphia of 1883 vintage
(General Electric photo

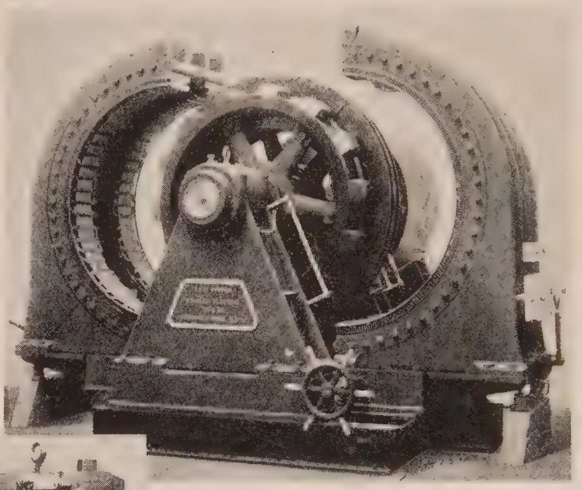


(Left) An early 350-kw Parsons steam turbine driving 2 700-amp 250-volt dynamos. This unit was brought to the United States from Newcastle-on-Tyne, England
(National Carbon Co. photo)

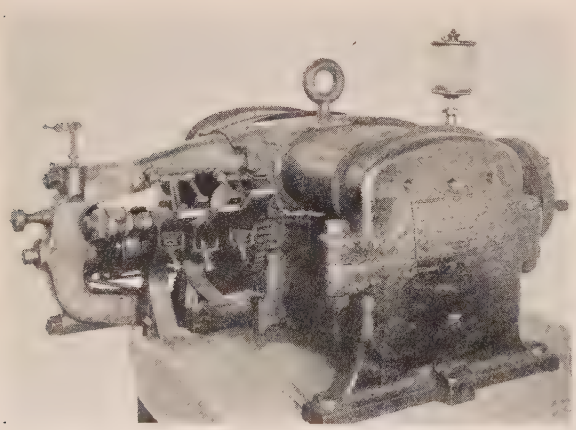
Generators



A 5,000-kw 500-rpm vertical generating unit installed at the Fisk Street station of the Chicago Edison Company in 1903; it consists of a 2-stage Curtis turbine direct connected to a 9,000-volt generator. This machine is one of the first large units of its type and one of the largest of its day
(General Electric photo)

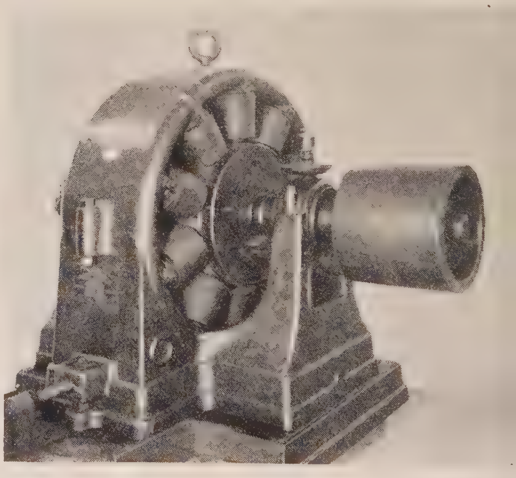


Original Stanley polyphase generator (armature drawn apart); this machine was wound for 6,600 volts and had a capacity of 600 kva; 3 of them were installed at the plant of Montmorency Power Company (Quebec)
(General Electric photo)

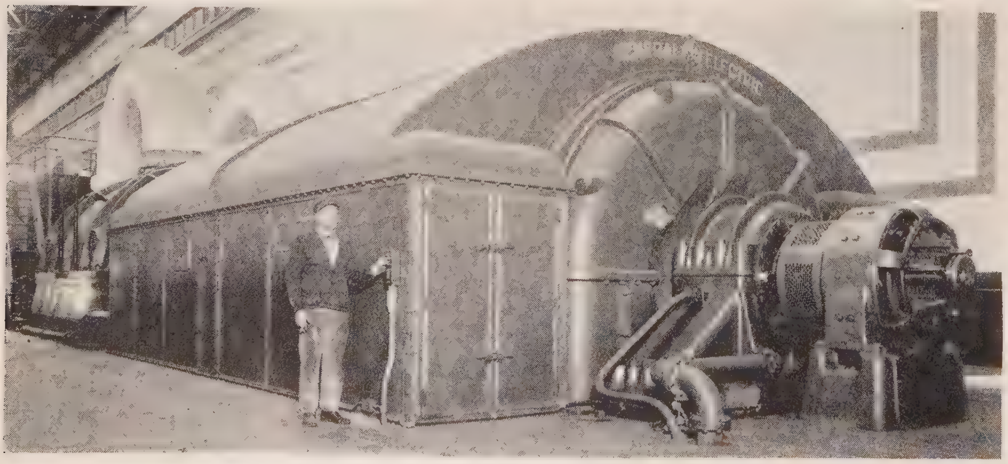


An early horizontal type d-c dynamo. This is a bipolar, double-magnetic-circuit machine, with 4 field coils, and was built in sizes ranging from 20 to 80 hp. This machine also was known as the Weston type; it sometimes was built with its long axis vertical
(Westinghouse photo)

An early Edison type "Z" machine built in 1883
(General Electric photo)

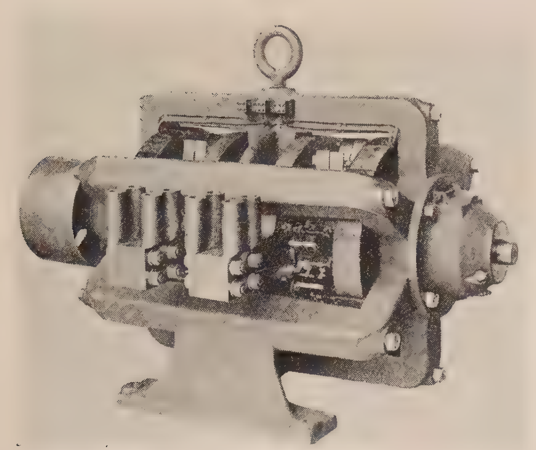


(Above) Original a-c generator, 1886–89. This was a single-phase 133-cycle 1,000-volt machine; it had a smooth armature core, covered with a single layer of wire. The bearings required frequent attention, being lubricated by drip from large oil reservoirs
(Westinghouse photo)

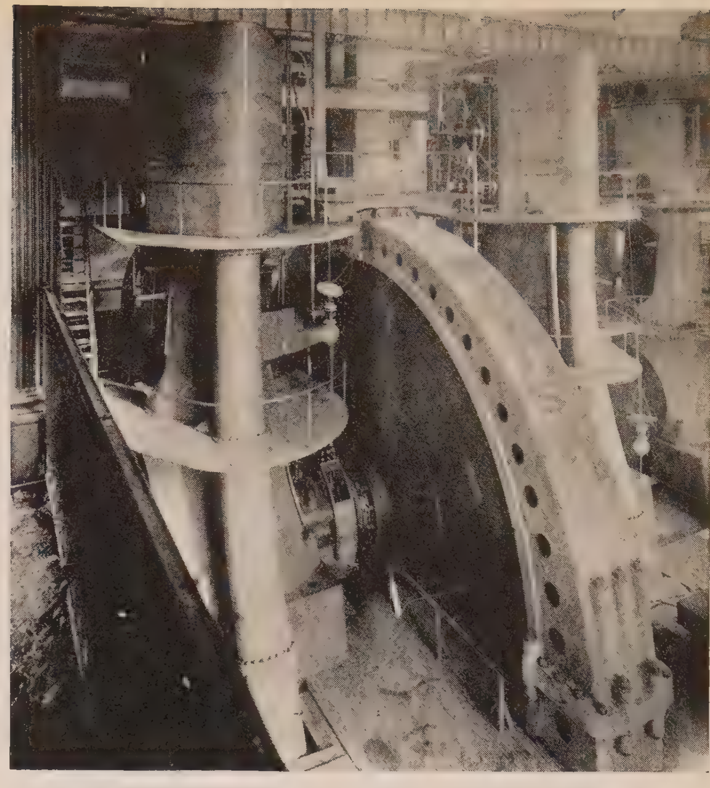


(Left) One of the largest of modern steam turbine generators is this 160,000-kw single-shaft unit in the East River station of the New York Edison Company; it was placed in service in 1929
(Consolidated Gas Co. photo)

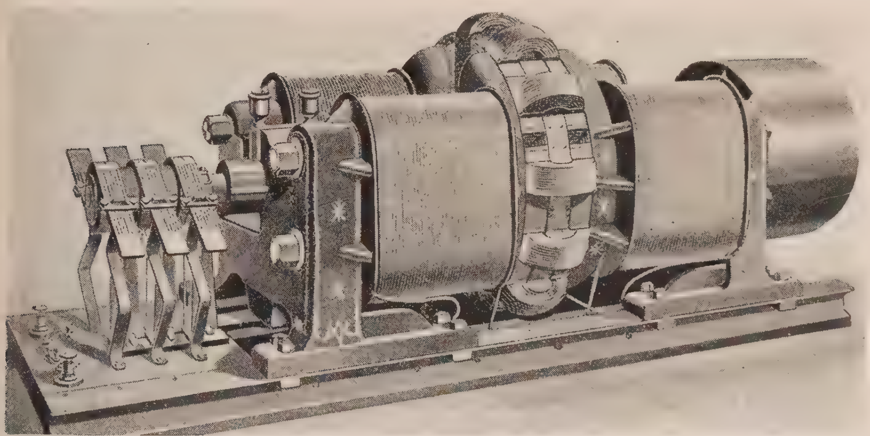
# of Various Periods



A unipolar or "homopolar" generator of about 1895. This machine, which generates direct current without a commutator, was built in sizes as large as 2,000 kw; unfortunately, however, it is practical for only very low voltages and consequently the demand was very limited. It is now a curiosity (Westinghouse photo

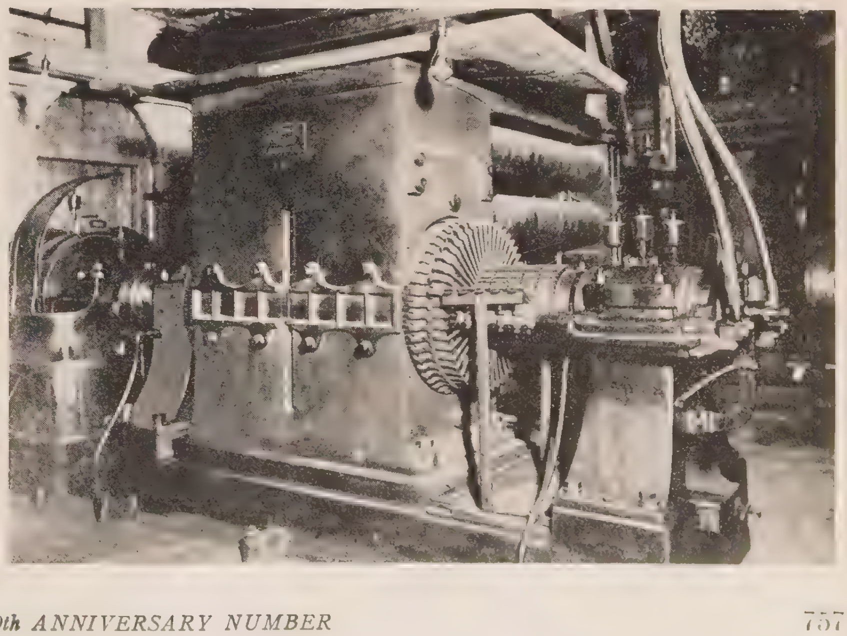


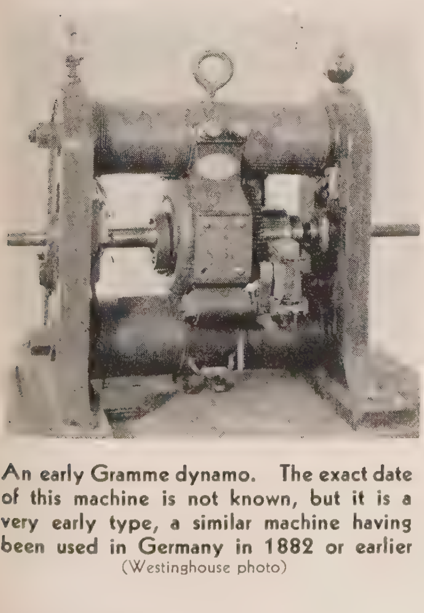
The engine-driven generator, before the coming of the steam turbine, grew to very large sizes. This machine, one of the largest of its type, is a 5,000-kw unit built in 1901 for the New York City Elevated Railroad; the diameter of the generator is 43 feet. Machines of this type were very common prior to 1900
(Westinghouse photo)



A Brush arc dynamo, one of the early types of generators designed for operating arc lamps in series
(National Carbon Co. photo)

The first Edison jumbo dynamo that went into operation in Thomas A. Edison's original central electric light plant, the historic Pearl Street station in New York City, on September 4, 1882. This is the only one of the 6 original dynamos that is still in existence. It is now in Henry Ford's Edison Museum at Dearborn, Michigan
(Consolidated Gas Co. photo)





An early Gramme dynamo. The exact date of this machine is not known, but it is a very early type, a similar machine having been used in Germany in 1882 or earlier
(Westinghouse photo)

Some High Lights of Electrical History

By Elihu Thomson, President A.I.E.E. 1889–90

These personal reminiscences by a widely recognized leader in the electrical engineering profession touch upon some of the significant developments in early electrical equipment, and reflect many of the colorful personalities involved. This manuscript is based upon the record of a recent interview by Prof. D. C. Jackson.

OUR AMERICAN Institute of Electrical Engineers has now been in existence for a period of half a century, a period covering nearly the whole of electrical application from the time when there was little electrical engineering proper, to and including the major advances which it is the function of our Institute to discuss at its meetings and record in its literature, covering many volumes of proceedings.

As one of the surviving "old timers," I have been requested to outline, from my knowledge of the art, the conditions preceding the period about 1884, when the American Institute of Electrical Engineers began to take shape, a period which would precede the first electrical exhibition held in the United States, sponsored by the Franklin Institute in the fall of the year 1884, and called the "Electrical Exhibition." From that starting point, I shall proceed, in a sketchy way, to tell of the inception, the growth, and the important events in our art, which have characterized one of the major business enterprises with which I have been connected a little more than the full half-century.

I had been, in 1884, for a long time associated as member and as one of the board of managers of the Franklin Institute, and was accustomed to present papers on any new matter that we had been investigating. These papers were presented at the monthly meetings.

Developments Prior to 1884

I may now be permitted to make a brief statement of the conditions regarding the generation of electricity from power prior to the date mentioned, and, of course, subsequent to Faraday's discovery, in 1831, of the conversion of mechanical power into electric current. A great deal of information on this part of the subject is to be found in the two large volumes on "Electric Illumination" by James Dredge published in 1882, much of the material of which is stated to have been taken from the journal *Engineering*. The subject "electric illumination" refers, in fact, to the early efforts to use mechanical power to drive dynamo-electric machines, now called electric generators, and the purpose of the currents so generated was to furnish the electric energy for lighting. It is true that the earliest of these machines or generators comprised both the direct current and the alternating current types. There were several forms of these machines, which consisted mostly of revolving coils in the fields of permanent magnets, and they were applied mostly where a large unit or source of light was needed, such as a large arc, and used chiefly in lighthouse service. Such were the Clark, the Alliance, and the Holmes types of machines. These were followed by the Pacinotti, which was, of course, direct current and laid the foundation for such generators or dynamo machines as the Gramme. There were also the Wilde and Ladd machines, to which I will refer briefly later.

A significant committee was called about this time, which became known as the "C. G. S. Committee," establishing as units measures based upon the metric units, centimeter, gramme and second; the centimeter being the unit of length, the gramme being the unit of weight or mass, and the second the unit of time. This committee included such men as Weber, Gauss, Sir William Thomson, Prof. G. C. Foster, James Clark Maxwell, G. F. Stoney, Prof. Fleeming Jenkin, Dr. Werner Siemens, F. I. Bramwell, and Professor Everett, who was secretary of the committee. The work of that committee was followed, in part at least, by the subsequent electrical congresses in the different countries, usually associated with the great international expositions.

Until the invention by Gramme, in 1871, of the Gramme machine, the continuous current dynamos or generators were such as the Wilde and the Ladd. I happened to be present at an exhibition in Philadelphia in which a Wilde machine was shown, which had been acquired from abroad for the University of Pennsylvania by Prof. Robert E. Rogers, of the department of physics, and I remember the thrills that I experienced in seeing it operate giving direct current and heating a strip of metal to a bright red heat when driven by the power of 2 men. I seemed to feel in this exhibition, modest as it was, that there was the beginning of our art so far as continuous currents were concerned. However, this comparatively crude machine was soon followed by the Gramme, involving the principle of commutation set up by A. C. Pacinotti some time before. The Gramme machine was at once recognized as a type far more perfect for continuous current generation than anything that had appeared before, and while it was developed in France, there were occasional instances of such a machine having been

brought to America. I may add here that it was recognized as perhaps the most perfect type of continuous current machine when announced in 1871 by Gramme.

NOTE—To anticipate, in 1889, at the Paris Exposition, I was invited to take luncheon with the electrical jury, and Gramme was present. I was told that it was very difficult to get him out, and that it might be considered a most exceptional event that he had appeared on this occasion.

The Gramme machine became known in the literature in the early 70's of the last century, and was followed by modifications, such as the Wallace-Farmer machine, made by Wallace & Sons, of Ansonia, Connecticut. It also was followed abroad, as in England, by R. E. B. Crompton taking up and manufacturing the Bürgin machine, which was like the Gramme except that instead of a single iron wire ring with the armature coils carried thereby, there were several rings consecutively placed on the shaft. The copper wire coils of these rings, few in number on each ring, were connected up to a commutator which was practically like the Gramme or Pacinotti. Colonel Crompton still lives in London at the ripe age of 90 years.

Then came the Siemens machine with its cylindrical armature, similar to the Weston, followed by the Brush machine, which, while it had an armature in the form of a ring, was peculiar in its commutation and not at all like the Gramme.

It should be noted here that during the Exposition of 1878 at Paris, the Avenue de L'Opera was lighted, as well as the Place de L'Opera, by a system which existed only for a few years, namely, the Jablochkoff. As I was in Paris at the time, I was able to form an estimate of the possible future of the Jablochkoff system of lighting. It was based on the use of parallel carbons in what was called the Jablochkoff "candle," and these were operated by alternating currents from stations nearby. These stations had been furnished with dynamos which were based on principles similar to the Gramme, but without the commutation. I remember also that one of the railway stations in Paris, I think the Gare St. Lazare, was lighted by a series of arc lamps of the Lontin system, about 6 or 8 in number, during the exposition time, and so far as I know, this was one of the early cases of the use of arc lamps in series. Crompton, in London, I understand, in applying the Bürgin type of dynamo to lighting, did not limit himself to a single lamp, but the machines were made of sufficient voltage to operate 2 or 3 or more in series.

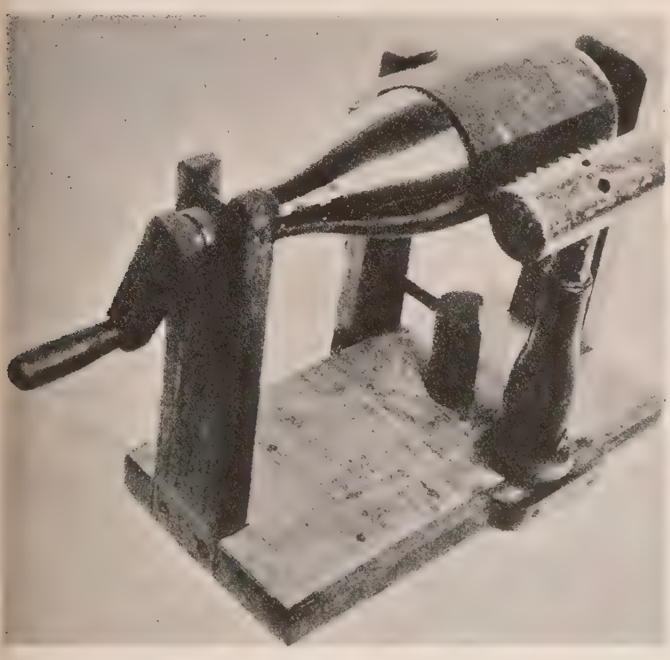


Fig. 1. A model, part of which is the original, of a wine bottle frictional static machine built by Professor Thomson when 11 years old

I can say that at least 10 years before the formation of the American Institute of Electrical Engineers, I began the construction of small model dynamos and armatures. From 1873 up to 1875, I remember making a small dynamo with a Gramme ring, and comparing its operation with the same machine in which the armature of the ring type of Gramme was replaced by what became known as the Siemens armature, though at the time I thought I had invented it, until I had looked it up in the British patents. It was the drum armature, so-called, and the comparison really favored the Siemens type. I still possess this small example of early construction.

Early Experiments in Electronics

Prof. E. J. Houston and I had become associated in electrical work, he being at the head of the physics department, and I teaching in the chemistry department of the Boys' Central High School in Philadelphia, Mechanics being one of the subjects that I taught, and any new ideas which came to us were discussed together. It happened that, about 1875, it was announced by Edison that he had discovered a new force, which he called "etheric force," because it showed no evidence of polarity, plus or minus, positive or negative, and would not affect any of the instruments then in use for detecting electric current. A considerable amount of interest had been taken by the newspapers in regard to this alleged new force, or "etheric force," and, as was natural, Professor Houston and I discussed the matter. I remember saying to him, "That is not a new force; that is electrical, and we can easily prove that it is so." This led to a series of experiments in which finally the discharge of a large induction or Ruhmkorff coil secondary across a spark gap produced sparks about $1^1/_2$ or 2 in. long, from an improvised condenser which consisted merely of a tin vessel supported on a glass jar attached to one of the terminals of the secondary of the induction coil, while the other terminal was grounded on a water pipe beneath the desk or table. This apparatus being set into action, we explored the whole school, which was quite a large building, and found that we could pick up tiny sparks from metallic objects all through the building, which had many rooms and a basement, and that even at the observatory at the top of the building, nearly 100 ft away, these same

indicating sparks could be drawn from almost any metallic object, proving that the "etheric force" was merely rapidly reversed electrical impulses sent out, clearly an embodiment of the subsequent wireless work. We had no doubt at the time that we could have gotten these tiny signal sparks, as we might call them, from any location, even outside the building, if not too far away. Our experiments provided the missing polarity, and showed that a proper instrument would have responded to the waves sent out by each spark. These experiments were described in the *Journal* of the Franklin Institute, and the article was reproduced in the *Scientific American Supplement* No. 21, issued May 20, 1876.

This account would not be complete without brief reference to the conditions in which I was personally concerned, which led me into the art of dynamo construction and arc lighting. At the Centennial Exposition of 1876, there were, as I remember it, 3 exhibits of dynamos; one was the very interesting Gramme exhibit, sent over from Paris and occupying a small space in Machinery Hall; another was a Wallace-Farmer machine, used to provide current for a single arc light; and the third was a solitary machine which I understood had been built at Cornell University by Prof. William A. Anthony, physics professor there, who afterward became a President of the Institute. It was substantially of

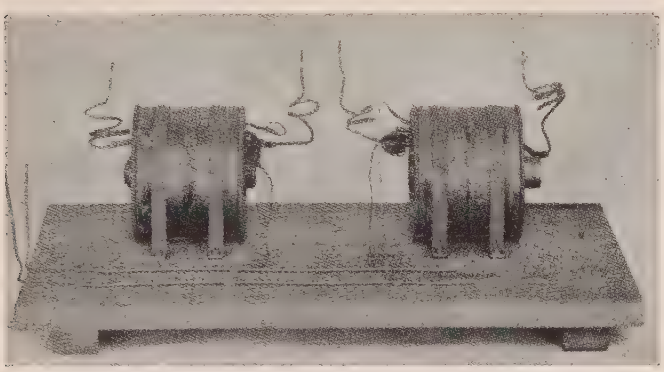


Fig. 2. Experimental pair of transformers as used at the Franklin Institute, Philadelphia, January and February 1879, in pioneer a-c experiments

Gramme construction. When the exhibition had closed, some of the lighting of the building was taken care of by Brush machines temporarily, a single arc on each circuit.

It had been proposed at the Franklin Institute to appoint a committee on Dynamo electric machines, so that measurements of power taken to drive them, measurements of electrical energy used in the various parts of the circuits of the dynamo, especially in the arc circuit, measurements of efficiency in the conversion of power into electrical current energy, and such other things as might seem of interest and of value in regard to the growing importance of such machinery, should be made. These tests were made on several machines offered for test in the early part of 1878, and the record of this may be found in the Franklin Institute *Journal*, "Report of the Committee on Dynamo Electri[c] Machines," so that I need not go into any furthe[r] detail here.

Early Lectures and Experiments

It is proper that I should mention in this connec[-]tion that I was requested to deliver a course of [5] lectures early in 1877, at the Franklin Institute dealing with electricity. I took for my genera[l] theme in these lectures the idea that electricity fro[m] any source, however produced, was the same in es[-]sence and obeyed the same laws. This led me to d[o] some things which I believe had not been done be[-]fore, such as reversing a Ruhmkorff induction spar[k] coil by sending a high tension discharge from a Leyde[n] battery through the fine wire winding, and notin[g] the effects in the coarse wire primary, so-called which now became the secondary circuit. As th[e] induction coil itself would be subjected to som[e] strains which might even break it down, I used i[n] this case a coil that I had built for my own use, an[d] which I could rewind if anything happened to it[.] This reversal of the induction coil led to 2 things it suggested the idea of the electric welding trans[-]former, which experiment I need not describe, as i[t] has often been described; and it also led to the trans[-]former in which a high potential was put upon th[e] primary fine wire and the working current take[n] from a short conductor, which ordinarily is th[e] primary but now had become the secondary, leadin[g] at once to the idea of the potential reducing trans[-]former or transformer system. I need not dwell o[n] this experiment either, because it has been de[-]scribed, but each of these trials became the fruitfu[l] suggestions for later work.

The tests at the Franklin Institute naturall[y] turned my attention to the use of dynamos fo[r] working arc lights, and no doubt was a considerabl[e] factor which led to the invention of the Thomson-Houston 3-coil machine as a simple dynamo con[-]struction, from which we developed a constant cur[-]rent arc lighting system. I had found very soo[n] after running the first of this type of machine, tha[t] I could change the position of the brushes on th[e] commutator and even run the machine on a short circuit without increasing the line current and with[-]out any damaging effects.

The first machine embodying these principle[s] was built in a small machine shop in Philadelphia but when it was ready for test, we did not hav[e] power enough to drive it. However, we found [a] place for it in a bakery nearby where we were able t[o] run it, and this machine became known as th[e] "bakery machine." It is the one that is now at th[e] National Museum in Washington. When we cam[e] to build the machine, I had to do all the figuring and all the proportioning; in fact, all the engineer[-]ing. I wound every inch of wire on it, because [I] did not dare to have anybody handle the wire with[-]out knowing it was thoroughly insulated. We go[t] it running, and our backer, Mr. Garrett, came in on[e] day while we had 4 20-ampere arcs running fro[m] it. He said, "Aren't those lights rather large?" [I] said, "Yes; I thought you would need smaller lights

but we have no lamps to test this out. In fact, I have provided for the change to smaller current and higher voltage. The machine is double wound and has 2 wires instead of a single wire circuit running through it. I have only to make a few alterations in coupling these wires, but we have no lamps to make the test." Mr. Garrett replied, "I can borrow a number of lamps, and we can make the test and then restore the lamps to the circuits." With that, he brought along about 10 arc lamps of the Brush type, which, by the way, fitted nicely into our conditions, and in testing we found that at the speed we were driving the dynamo, which was unchanged from the time it was running the 4 lights, we could easily maintain, in a series, 9 arc lamps. This first machine, called the "bakery machine," the first of its type with the 3-coil armature winding, was already a well developed machine for quite a number of arc lamps.

During the time this machine was being run in the bakery, Houston and McCollin, the latter being associated with Mr. Garrett, would come in and find me there looking after the machine, and would say, "My, you will kill yourself," for the thermometer in the room frequently registered 140°F., and the only way I could stay there and watch the machine was by drinking ice water to excess. Before my blood became too hot I cooled it in this way and survived the heat with no ill effects, while both Houston and McCollin were forced to retire from the field because they were overheated; upset by something like sunstroke.

Garrett and McCollin carried on in Philadelphia the construction of machines that were very much like the "bakery machine," and Mr. Garrett started a small business of making and selling these machines with the complement of arc lights.

Design Controversies

It was about this time that our business was transferred to New Britain, Connecticut, the actual establishment of the business in New Britain taking place in the year 1880. A syndicate of local business men, headed by Frederick H. Churchill, made an arrangement with Mr. Garrett to take up the work for the United States, except for the middle states, which Mr. Garrett retained. While the business done in New Britain was not particularly active, and, in fact, was much smaller than it should have been with proper energy and devotion to the new enterprise, it did give me an opportunity for developing certain things that added advantages to what was then known as the Thomson-Houston system of arc lighting. It was fortunate that E. W. Rice, Jr., who was a young man just graduating from the High School in Philadelphia, associated himself with the enterprise, and by his energies was one of the greatest assets we ever had. Recipient of many honors, he became President of the General Electric Company, after having served for years as its technical director at Schenectady.

For a time there was a superstition that the wire over the ends of an armature, such as the drum (Siemens drum or Weston types) was idle wire, since it did not cut the lines of the field, and that, therefore, it would be proper to restrict its amount as far as possible. The correct view, which became the practice in Thomson-Houston designs, recognized the idle wire idea as unsound, and that the form of the armature winding depended on enclosing the maximum of lines of force or surrounding an area by the armature coil or coils as great as possible and

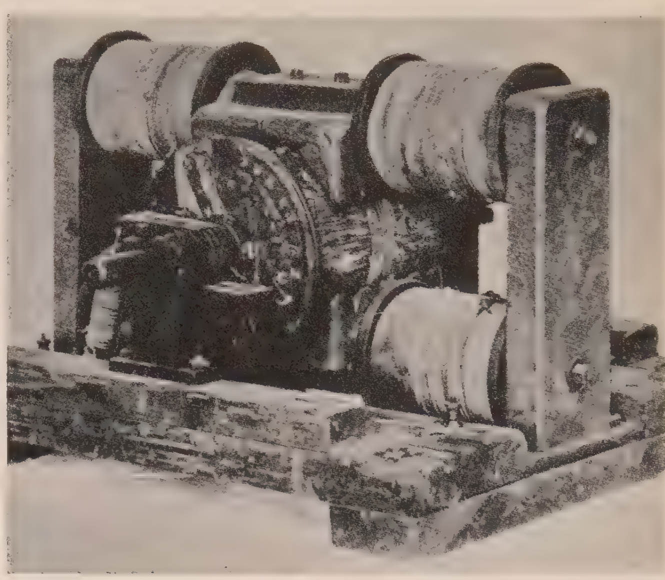


Fig. 3. Professor Thomson's 1878 a-c generator, first shown at the Franklin Institute in Philadelphia, where with 2 step-down transformers connected in parallel it lighted lamps

securing the benefit of a high peripheral speed in cutting the field lines. Hence, if more field lines at high speed could be cut, so much the better the design.

This principle was recognized in the "bakery machine" and in the Thomson-Houston dynamos built in 1879 in Philadelphia, and in the subsequent development of the Thomson-Houston system in Lynn, Mass., with its armature winding short along the axis. When this became generally known, the idle wire theory gradually disappeared, both in electric motors and in dynamo machines.

It was during this period that I designed and built the type of dynamo which became characteristic of the Thomson-Houston system; namely, the spherical armature type, which retained the 3-segment commutator and was provided with a perfected regulator for moving the brushes and keeping the current in the circuit constant, no matter what might be the load in lamps up to the capacity of the machine.

On p. 190 of Sylvanus P. Thompson's "Dynamo Electric Machinery," published, second edition, in 1886, he says:

Thomson-Houston Dynamo—This machine, which is equally remarkable, was designed by Professors Elihu Thomson and Edwin J. Houston, of Philadelphia. Its spherical armature is unique among armatures; its cup-shaped field magnets are unique among field magnets; its 3-part commutator is unique among commutators.

While the spherical armature machine was developed in New Britain, the capacity of any single machine was limited to 12 arc lights in series, the commutating limit, until during the stay in New Britain another important invention had been made; namely, the air blast for the commutators, the air blast being a device for inserting non-ionized or cold air at the breaks in the commutator, 3 in number.

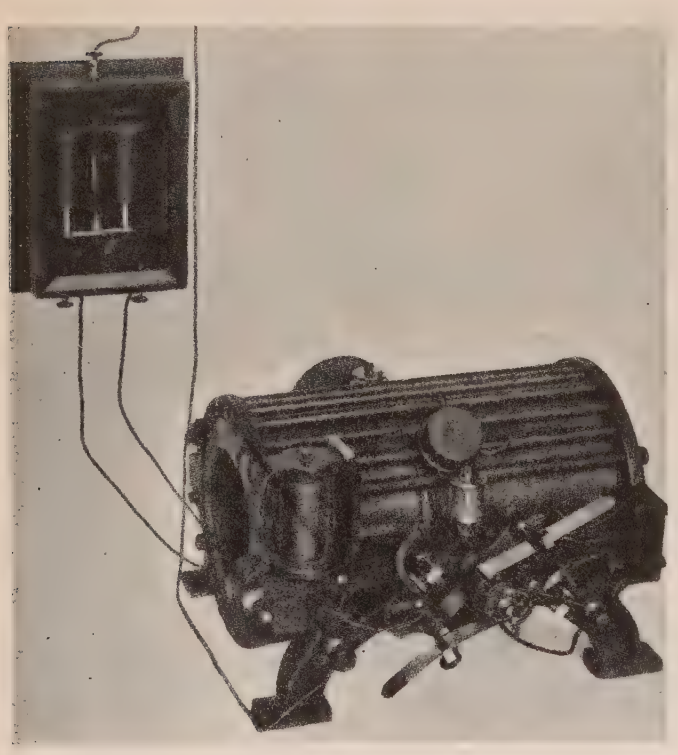


Fig. 4. A complete Thomson-Houston 3-coil arc dynamo with movable brushes and wall regulator

The number of arcs in series which could be operated from 1 dynamo was increased indefinitely, so that later on as many as 75 arcs were maintained from a single 3-segment commutator, and this arrangement permitted free oiling of the surfaces of the commutator.

Cincinnati Industrial Exhibition, 1883

In regard to the work in New Britain, it may be proper to mention that in 1883 there was held in Cincinnati an industrial exhibition. Electric lighting machinery being then quite novel, arc lights were naturally the subjects of investigation included. This led us to send to the exhibition one of our machines with its complement of arc lamps. The tests made were in charge of Doctors Mendenhall and Eddy, professors in the Ohio State University and the University of Cincinnati, respectively. Their report was favorable to our machine, which, in my judgment, I thought would be the case.

It was an era of intense rivalry. The Brush Company, Weston, ourselves, and others, were rivaling each other, and we were making all the good points we could for our own systems, of course. Some of the prominent electric lighting companies had, according to our view, no satisfactory arc system, one that met all requirements, and in 1882 we had a discussion with some of them in New York about the future of the art, etc. On going back to New Britain, I was called into a meeting of our directors and stockholders, and was presented with a contract all drawn up for me to sign, to cover future service. They would hire me for a certain amount to carry on the work, for so many years; and I said to myself, "What they are after is to put me on the shelf. They think they will satisfy me by giving me a contract for so much a year and for so long." "But," I said, "I see no preamble, saying that the company must carry on the work with due diligence, as per the first contract. That should be there." They said, "All that is understood." "Well," I said, "if it is understood, put it there." I was given to understand that Houston, being 8 years my senior, would be the hard one to deal with, but Thomson would be all right, and I thought, "I will show them. If that is the way they estimate me, they will get to know more." They said again it was not necessary. I said, "I demand it; that is the whole essence of the thing." We spent a whole afternoon arguing, and finally I picked up my hat and said, "Gentlemen, I am going. You need not expect to hear from me unless you put that preamble in the contract," and I left.

Some Early Commercial Developments

The next thing I heard was that the New Britain people had sold out to the Brush Company, of Cleveland, Ohio. George W. Stockley, the head of the Brush Company, had bought a majority interest in our stock. I met him in New Britain, and I said, "Mr. Stockley, do you know what you have bought? You have bought a law suit, and you are bound to lose out on it." I said, "Please look at this contract." I pulled out the original contract; "If the business is not carried on with due diligence and the proper expenditure of time and money, the patents revert to the patentees on presentation of their stock." He read it, and said, "I wouldn't have touched it if I had known that was there; I wouldn't have had anything to do with it."

That is the time that the Lynn people came along; S. A. Barton, H. A. Pevear who was our first President when we got to Lynn, and C. A. Coffin, about 7 or 8 in all; we called them the "Lynn Syndicate." Their interest in our apparatus came about in this way. A promoter named Edwards H. Goff, had bought one of our little machines of several arc lights capacity, and to interest the public had put it in the basement of a building on Tremont Street, in Boston, and so wired it as to put 2 of the lights outdoors. They were good steady lights, and attracted attention, including that of the gentlemen from Lynn, who said, virtually, "Why can't we get this kind of a system for Lynn?" Barton wanted it for his store, and the others were also interested. They happened to look at the nameplate of the dynamo as run in Boston, and found this inscription, "Manufactured by the American Electric Company, New Britain, Conn."

Silas A. Barton and Henry A. Pevear at once made a trip to New Britain, and there met E. W. Rice, Jr., who showed them our apparatus and system. Mr. Rice told them the whole story of how the business stood, and they said, "Why can't we get into this thing?" He told them that he thought that under proper circumstances I would join hands with them and be very glad. That opened the way for the Lynn people to buy the majority interest in the American Electric Company. In fact, they bought Stockley's stock. I made it clear to them that if they bought Mr. Stockley's interest and carried on the business as we hoped it would be carried on, we would join heartily with them, of course.

Thus began the works at Lynn, in 1883. The Lynn contingent built a factory, stocked it with tools, and we soon found that Mr. Coffin was a wonderful man, a business genius, who would come into the works and see us at work at some new thing, and would say, "How soon will you have it?" "Well, we will do it as fast as we can," would be the reply. He would say, "Go ahead and do it, and don't mind the expense; do the thing you think is right." When it came to the street car business it was the same thing, "Go ahead and do it." The foundation of our enterprise in 1882 was the Thomson-Houston arc lamp system.

The Arc-Light Era

In the exploitation of the arc system, we had adopted as a standard current value 9.6 amperes for the larger lights, and 6.8 for the smaller lights. These were always run in series, and the arc lamps could be exchanged from one constant current circuit, say 9.6, to another circuit of 9.6 at will. In the same way, the voltage across the arc was standardized so that the arcs in one of these circuits could replace any others; they were interchangeable.

It also may be mentioned, as an interesting fact, that from the start of our business we had provided on each arc lamp shunting switches, so that if a lamp was not needed, or was to be extinguished, it was necessary only to close the shunting switches or close the shunts around the lamps to be cut out. These advantages were, indeed, very much appreciated, and gave exceptional status to our arc lighting system. The possibility of their being used in this way, of course, followed upon the standardization of the current by the regulator, notwithstanding the changes in the load on the dynamo or on the constant current circuit, or fluctuation of speed in the dynamo.

In the arc lighting field, naturally the Brush Electric Company and the Brush arc system and the Thomson-Houston system operated the majority of arc lamps throughout our cities, the Thomson-Houston system continually gaining, so that in a few years it became the one most extended in use.

While our first arc lighting work included only the d-c carbon arc, this was, as time passed, substituted by the enclosed carbon arc, the luminous arc in which the arc flame itself was the source of light, carrying, as it did, refractory luminous particles, and later by the magnetite arc in Schenectady, as invented by Dr. Charles P. Steinmetz, many thousands of which went into use. We soon took up a general business, including electric motors for d-c and a-c circuits, and the great variety of electric appliances suitable to be worked on the circuits, a-c, d-c, etc. The development and application of the a-c constant current transformer for working the street lights was not the least of these developments, and will probably continue for many years ahead.

The exhibit of the Thomson-Houston Electric Company at the Franklin Institute's electrical exhibition in 1884 comprised several features that had been developed from time to time. For example, the slow feed that was required in arc lamps for the upper or movable carbon, with its holder, was secured by a very simple device which we designated the elastic support of the clutch, and which, in non-critical commercial language, gave what was known as a "sneak feed."

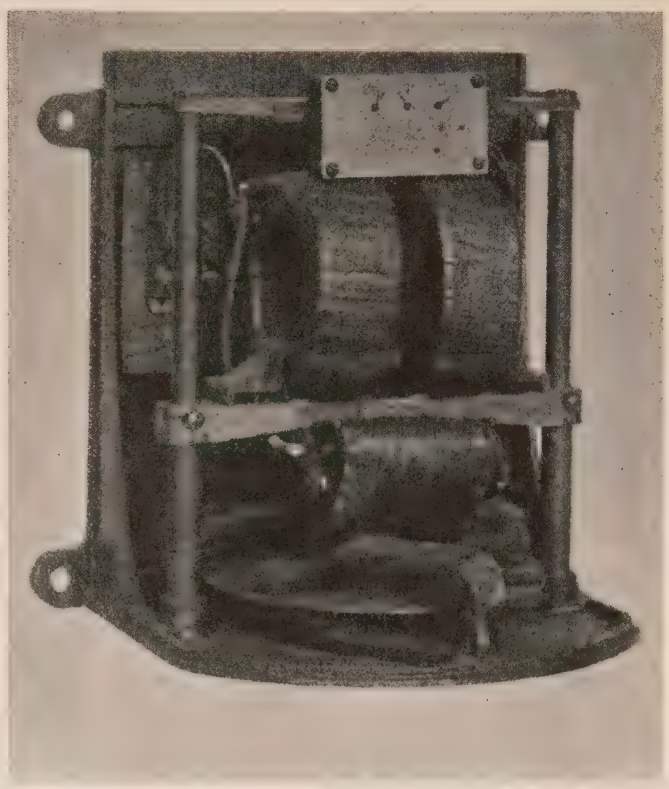


Fig. 5. Early Thomson recording wattmeter that shared first prize in Paris meter competition of 1890

Sometimes it was an apparently small thing, a matter of proportioning, perhaps, that would determine the future history in the practice of our art. Very early in the Thomson-Houston development in Lynn, Mass., came the simple yet effective device called the film cut-out. It was especially applied to a system of incandescent street lamps, in which several series of lights were worked, the film cut-out being placed in the base of each lamp so that if a filament broke an instantaneous shunt around that particular lamp was established, leaving the rest of the system intact.

Again, we developed the contactor control system, which is described in Thomson United States patent No. 617,546, of January 10, 1899, and has

been used widely in the control of trains embodying motor units on several cars of a train of passenger coaches, such as in the elevated train in cities, etc.

Some Early Transformer Developments

Another important invention which was developed along about this time, and which had been applied in New Britain on switches and lightning arresters and controllers for circuits, was the magnetic blowout, and during the period of the development at Lynn, the transformer system which I had created and tried out at the Franklin Institute in 1879 was brought to the point at which it could be commercially used. Although it was the opinion of many that the alternating current with high voltage primary circuits and low voltage secondaries for feeding the local load was dangerous, on account of the possibility of leaks from the high voltage to the low, I withheld the Thomson-Houston Company from going into the field until I could develop proper safeguards, 3 of which were worked out; chiefly the grounded secondary, which became practically universal, having been at first condemned by the underwriters, then tolerated, then recommended, and finally becoming mandatory. This history of the safety grounding gave rise to a resolution by the Western Association of Electrical Inspectors, at its 20th annual meeting, in which they designated me as the "father of protective grounding," the date being September 2, 1925.

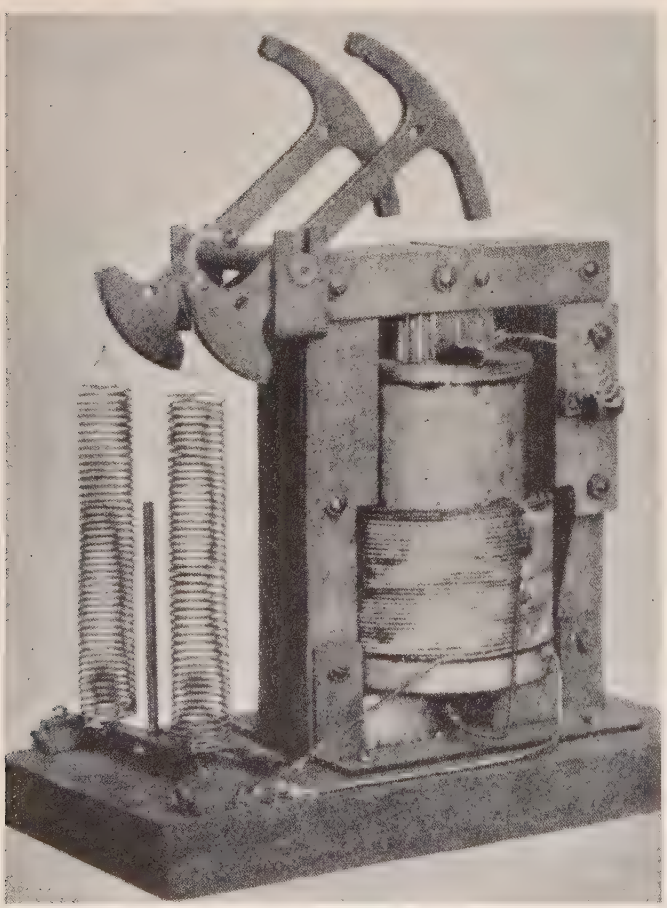


Fig. 6. Early model of Thomson constant current transformer

It may be mentioned that the transformer system was completed by the oil immersion of the coils of the transformer and the cooling of the oil by circulation of water, the large and later developments of which have been perfected at Pittsfield, Mass., the seat of the transformer manufacture of the General Electric Company.

Among the many important developments has been, of course, the alternating current motor, known variously as the repulsion motor, the shaded pole, etc. Added to this list of matters which were developed at West Lynn to a large extent, is a system of inventions beginning with the announcement of electric welding, first described in a paper in the *Electrical World* of December 25, 1886, and followed by numerous other modified or detailed patents forming the basis of the Thomson Electric Welding Company, of Lynn, which gave its attention to resistance welding, so-called, and which still carries on that special work under the name of the Thomson-Gibb Electric Welding Company.

The patent records, to show the activity in inventions during the period of business in Lynn up to the present, cover upwards of 700 patents issued to me in the United States alone, sometimes jointly with other inventors. The list of inventions was extended greatly, patents for other inventions being taken out in the individual names of the inventors. Naturally, this list does not include the inventions made at other works of the company, such as Schenectady.

It is an interesting fact, proper to be noted in this connection, that the Brush electric arc lighting system was later transferred, in its manufacture of Brush dynamos, to Lynn, and that many of the larger type of Brush arc machines were built there. Attached to these large generators or arc dynamos was a regulator which answered all the purposes and gave a new status to the Brush dynamos as built at Lynn, making the plant entirely automatic. This was accomplished by the Thomson-Rice Regulator, the patent for which was issued March 30, 1886, No. 339,079. This patent was taken out some time before the absorption of the Brush Electric Company, of Cleveland, Ohio, by the Thomson-Houston Company.

Electrical Measuring Instruments

When the New Britain organization was established in 1880, it was difficult to obtain any measuring instruments, or if they were obtained they involved a large expense desirable to avoid at the time the new enterprise was just beginning. Consequently my first piece of work there was to construct, by my own hands, measuring instruments in our little model shop. This involved the production of a Wheatstone bridge, of the single wire type, with slider; it also involved the production of standard resistances to use with the bridge, and these were copied from standard bobbins that were borrowed for the time, such as units of value, 1 ohm, 5 ohms, 10 ohms, or 100 ohms, etc. It also was found difficult to obtain

an ammeter for measuring current, so that an astatic galvanometer was constructed and employed in connection with the bridge, used for standardizing the voltage and the current flowing in the circuits. Within a short time, however, we made for service such instruments as Thomson-Rice ammeters and voltmeters, some of which are still in existence. There also was constructed, as early as 1880, a testing room dynamometer for measuring the power required to drive the dynamos under various loads. This also was used to measure armature losses.

During the early period from 1883 on, there were some carbon filament incandescent lamps, and a compound wound constant potential self-regulating dynamo adjusted to run at a standard voltage as desired. The brushes on the commutator of these machines were set in position and not changed for different loads, so that this constant potential dynamo, like the arc machine, was self-regulating no matter what the load, so far as the commutation was concerned, but, of course, there had to be provided the variation of excitation by the shunt field.

At the Paris exposition of 1889, and in the exhibit made there by the Thomson-Houston Electric Company of the various appliances and inventions, there were a few meters especially arranged to record the load on the secondary of transformer systems. The electrical jury were advised by me to pay no attention to the exhibit of meters, as there was soon coming a much more perfect instrument of the kind. It happened that the Paris meter competition was to be held the next year (1890) and that a prize of 10,000 francs had been set aside for the winner, or to be divided if there was more than one meter that met all the conditions, chief of which was that the meter should be available without change, on alternating current or direct current. I urged our people to enter the competition, because I felt fairly certain of winning at least a part of the prize. The result was that the Aron meter and the Thomson recording wattmeter were awarded each 5,000 francs, because both the Aron meter and the Thomson meter met the condition of being available on alternating current and direct current. The decision of the Paris meter commission was quite satisfactory, because it seemed inevitable that the simpler construction of the Thomson meter would win out commercially.

At the time of the International Exposition at Chicago in 1893, I happened to meet Prof. W. E. Ayrton, who had been appointed to head the electrical jury of awards. He told me that they expected to use our meter as a standard with which the others were to be compared. Until the development of the simple a-c wattmeters, this meter satisfied all the requirements.

International Coöperation

In the fall of 1884, and during the continuance of the Franklin Institute's electrical exhibition, there was called a conference of electricians to discuss such matters as would naturally fall to a congress of the kind; the use of terms, etc. Before that date, I had become familiar with the increasing growth of the electrical art, not only in the United States, but by visiting the Paris exposition of 1878. The conference of electricians at the Franklin Institute exhibition was the first general meeting in the United States, and was the forerunner of the international electrical congresses of 1893 at Chicago, and of 1904 at St. Louis. Other congresses were held abroad filling in the gaps, as it were, and at which some very important decisions were reached in the nomenclature and units of measure. Thus, the unit of current, which before that time had been called *weber*, was now changed to the *ampere*. It was natural that I should attend the early meetings of the infant society, The American Institute of Electrical Engineers, which has now grown to such great importance and includes an army of membership.

The records of the Institute itself will furnish such information as to papers and discussions in which I have taken part. When elected President of the American Institute of Electrical Engineers in 1889, I presided at one of its meetings at which I delivered a paper.* Later in the year, I went abroad to attend the Exposition Universelle at Paris. The well-known repulsion experiments with alternating currents were shown at this exposition for the first time abroad, as well as several devices based upon the discoveries made. They naturally attracted a great deal of notice here as well as in Europe, and formed the basis of many valuable devices, including the repulsion a-c motor.

Prof. J. A. Fleming requested that the repulsion apparatus, which included quite a series of embodiments showing the repulsion principle, be loaned to him so that he might present it in a lecture to the Royal Society of England. This was done in the famous Fleming lecture, and then followed the request that the set of apparatus be retained in England permanently in the Royal Institution, on the idea that Faraday's work would be supplemented for alternating currents, whereas his work had dealt only with direct current. This gift of the pioneer repulsion apparatus was made, accordingly.

It happened that while I was in Europe, in 1889, I was called upon to represent the A.I.E.E., being then its President, at a conference of a body of engineers in London. This meeting comprised about 300 visiting Americans, including many men at the head of our engineering and manufactures, along with 300 or so British representatives of the arts and industries. It was particularly desired of me that I attend the Guild Hall dinner, as the Institute's first representative abroad. There was a list of speakers representing the British side, as also others representing the American visiting engineers. In a body of the size (600) it naturally became a difficult matter to have the speakers dominate the situation, or speak loud enough to reach the members present and prevent their going off into a buzz, and this is the humorous part of it:

One of our American college professors who was present was seated at the head table several places to the left of my position, and he passed me a note

* Professor Thomson's first formal paper before the Institute was the classical paper entitled "Novel Phenomena of Alternating Currents," presented at the General Meeting on May 18, 1887.

while one of the gentlemen representing one of our metal industries was speaking. It was notable that this man's voice did not reach many feet away from his position at the head table. The professor's note reminded me of the fact, and to quote him (those present were paying little attention to the speaker, and the whole room was filled with a buzzing mass of humanity who, not being able to hear, naturally fell into conversation with neighbors), "Thomson, it is your turn next, and for the Lord's sake, get them back!" I answered his note, "I will if I can." The denouement was that I did get them back, and had the attention of the body present in a few minutes after I began, but it required a tremendous effort of the lungs to reach the more distant part of the audience.

I am reminded that in one of the discussions printed in the JOURNAL of the Institute, reference was made by me at some length to a steam engine of high economy, which was not even condensing, but exhausted its steam directly from the cylinders. We were surprised to find that the same type of engine sometime later was announced to the world as the Stumpf uniflow engine, showing high economy, and that other engines of similar type, one called the "unaflow" instead of uniflow, appeared in the steam engine art. I have at least the satisfaction of having brought this type of engine to the knowledge of the membership of the Institute, describing its construction and its properties before it had been christened the "unaflow" or "uniflow," but I was not present at that ceremony. It was developed by me at the Lynn Works of the General Electric Company.

Some Railway Developments

I should not leave this account without reference to another important event, which practically started the work of electrification of street railways by the Thomson-Houston Company. The company already had made arrangements with Bentley and Knight in connection with railway problems, but Mr. Coffin took the position that the wisest and speediest method would be to acquire an active business from some one of the concerns already specializing in that work. He asked me, "Thomson, who is there that has done pioneer work in street railways?" "VanDepoele, of Chicago," I answered. Said Mr. Coffin, "What has he accomplished; how is he getting along?" I said, "He has done much good work, but I believe the conditions of his organization are not satisfactory to him." Mr. Coffin then asked if I thought he would come on for a conference, to which I answered in the affirmative.

On invitation, Mr. VanDepoele did come on to Lynn, and we met in Mr. Coffin's house. Mr. Coffin was soon satisfied that Mr. VanDepoele was, indeed, a valued pioneer in street railway electrification. The business of VanDepoele then became part of the work of the Thomson-Houston Company, especially in the engineering organization. Unfortunately, Mr. VanDepoele contracted an ailment, severe muscular rheumatism, leading to his untimely death, but he had left his impression involving the under-running overhead trolley and the carbon brush. Elsewhere the complete history of the application of our introduction of the carbon brush to electric railway motors is to be found, and need not be repeated here. This use was a suggestion of VanDepoele's. In the same way, the carbon brush became an essential to commutation in the power station dynamos, and, indeed, the almost universal application of the carbon brush in dynamos and motors of the continuous current type followed.

Fig. 7. Professor Thomson and his first (1886) electric welding transformer, with single turn secondary

It is well known that under the circumstances existing in 1891–92, it was desirable that an organization should exist which would supplement the work of such a company as the Edison General Company, which had opposed the use of alternating currents on the ground of danger. It was thought desirable that a company in the expanding field should not be limited by the opinions that this or that should be avoided, when proper safeguards were established. This was the case with our safety devices for alternating current and transmission by transformers at high potential to be lowered at the consumers' end to the potential desired in the apparatus used. This condition was brought to the notice of some of the most important business men in the Edison company, and, of course, the Thomson-Houston Company was informed. Not to go into the details, it was determined by the Edison General Company that it would accept the conditions which would make a well rounded-out organization. Mr. Coffin was called upon, as the leader of the Thomson-Houston Company, and his broad view favored the consolidation of the two companies. Thus, negotiations followed whereby a number of the Thomson-Houston officials became the leading officials of the new organization, the General Electric Company, with Mr. Coffin as its president. In this way, the field for expansion of the electric lighting and power industry was stripped of some limitations, which before had stood in the way.

At the beginning of the present century, I was re-

quested to furnish an article to the New York *Sun*, dealing with the advances in the electrical work that had characterized the century before 1900. That task I undertook, and the article was widely published.

Mention has been made of the International Congress of Electricians, which met in St. Louis in 1904. It happened that I was made the president of this Congress, with a very efficient secretary, Prof. A. E. Kennelly, and treasurer, William D. Weaver who had long been connected with the finances of the Institute. Due to their untiring devotion, the congress was quite a success.

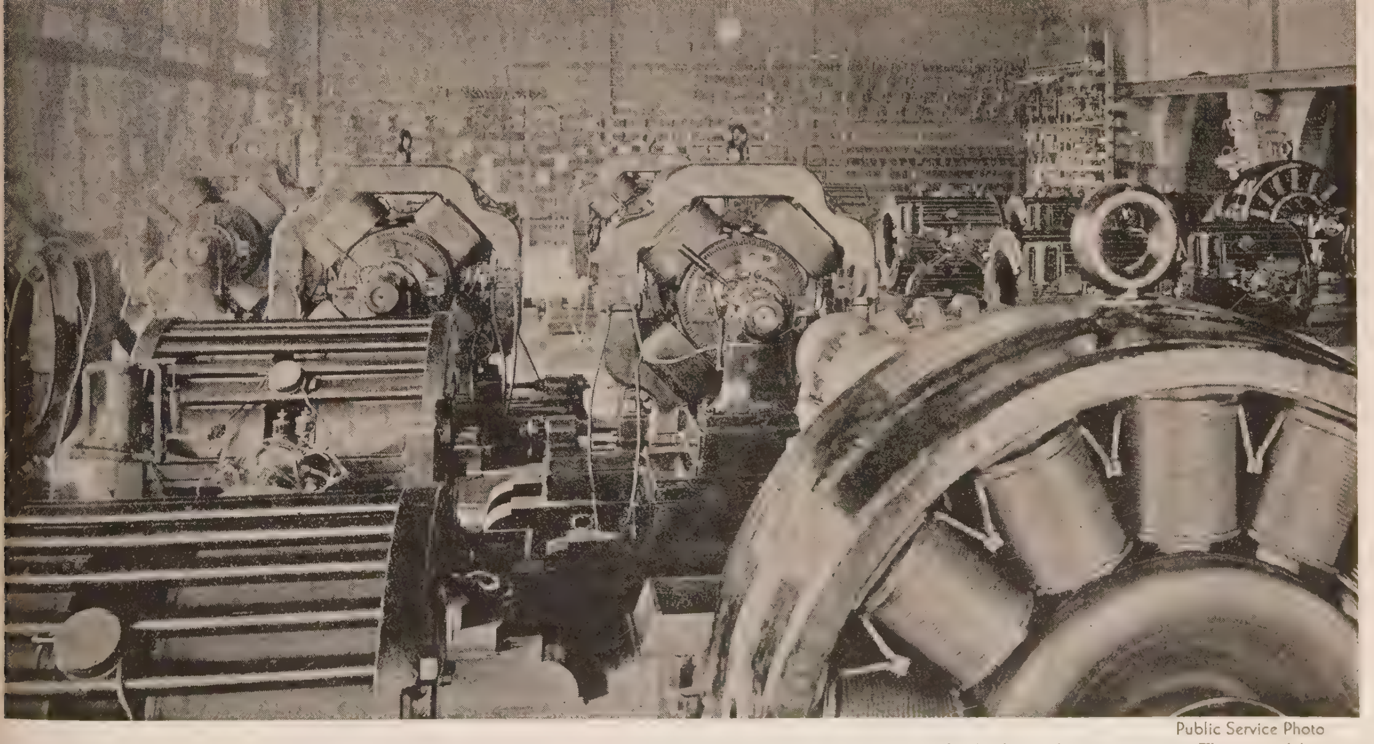
The organization that was started in St. Louis at the time of the exposition was, on the recommendation of some of the members of the congress, made permanent, taking the name of the International Electrotechnical Commission, with Lord Kelvin as its first president, followed by Prof. E. Mascart, who did not, however, survive to take the office. After the death of Mascart, I served the commission for the prescribed period of the presidency, and a permanent secretary, C. LeMaistre, was chosen. Much valuable work in unification and standardization has been carried out by this body, the work of which has continued since that time.

I need hardly say anything to emphasize the valuable work done by the American Institute of Electrical Engineers, as the leading body of electricians and engineers in the United States, during the past 50 years, and which led to the establishment of the Engineering Societies Building at 39 West 39th Street, New York City. The organization now includes a membership of more than 15,000. I need not call the attention of the members of the Institute to the several affiliated bodies having charge of awards: The Engineering Foundation, established by an original gift of $500,000 by Dr. Ambrose Swasey, The American Standards Association, The American Engineering Council, The International Electrotechnical Commission, and many others.

This personal review has naturally been limited to accomplishments growing out of the work of but few persons, and it must be understood that similar histories could be provided by the leaders in the many other organizations of similar character throughout our country, as well as the world. The attempt has been to produce a record which can be referred to by the younger men who devote themselves to electrical applications and enterprises, such as have been the work of the past.

It is natural that numerous technical, or partly technical, papers would have been communicated by our profession of electrical engineering to the societies over so long a period as a half-century. The proceedings of the American Institute of Electrical Engineers contain a most valuable record of the progress in the electric art, and the discussions held at its meetings and embodied in its records have had a profound influence in emphasizing the important steps in the development that has taken place. Can we doubt that this record will be continued in the next half-century?

Interior of the Hoboken Station of the Hudson Electric Light Company in 1897

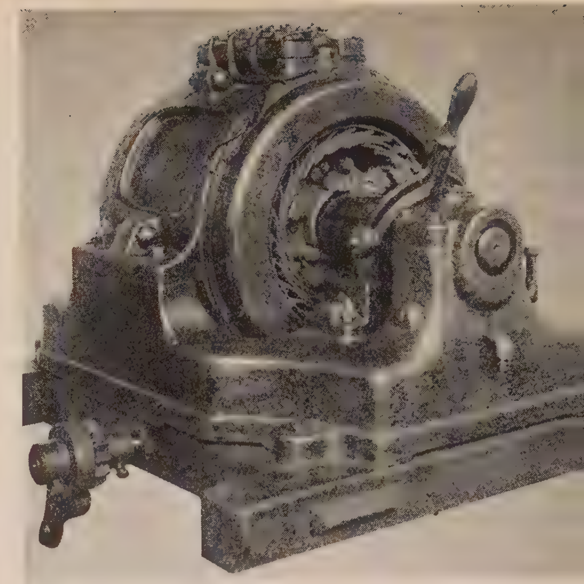


Public Service Photo

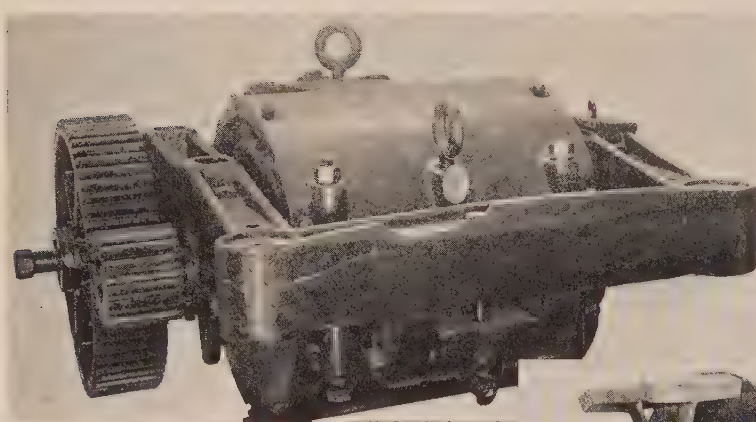
This station was placed in operation in 1892 and shut down in 1902. The machines in service, most of which can be seen, were Thomson-Houston (4) 1,000-volt 2,000-light, (10) 4,000-volt 80-light, (5) 500-volt 100-kw d-c, and (3) 500-volt 500-kw d-c generators; a Brush 125-light arc machine; and 2 Edison exciters

Typical Electric Motors

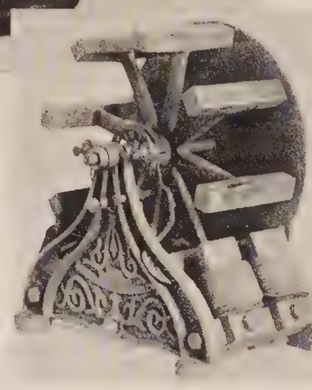
In addition to the electric motors shown on this page, other rotating equipment is shown on pages 754–5 and 756–7



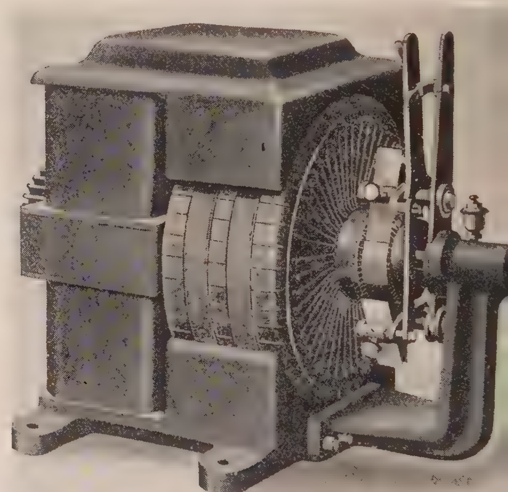
One of the first polyphase induction motors to b placed in commercial use—a 5-hp, 110-volt, 50 cycle machine installed in 1893 and operated unt June 1925 (General Electric phot



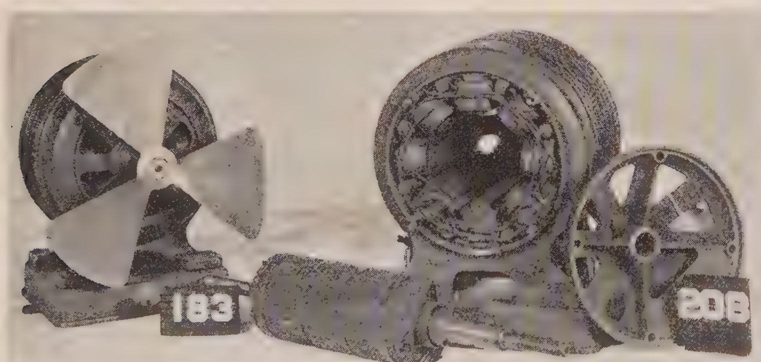
(Above) Said to be the "progenitor" of the present d-c railway motor this 1891 motor embodied the slotted armature, symmetrical 4-pole field, single reduction gear, and ironclad construction now universal Westinghouse photo)



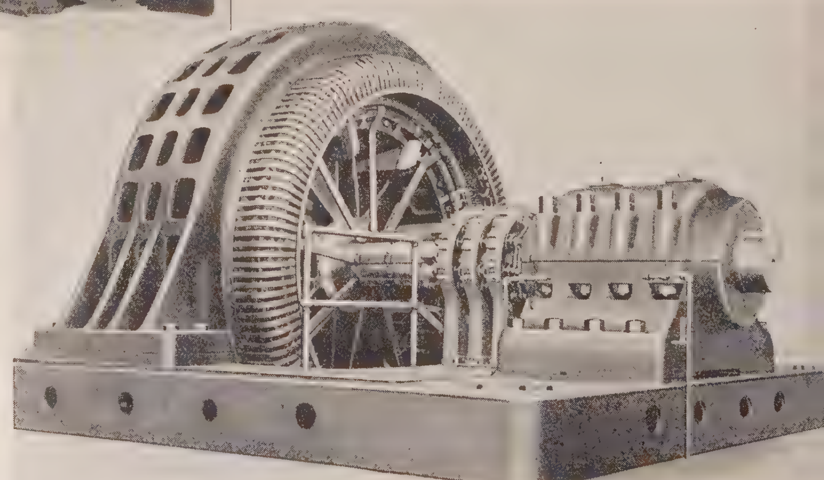
(Right) The Bastet magnetic engine built in 1874, one of the earliest known motors produced commercially
(National Carbon Co. photo)



An early Van Depoele electric railwa motor—equipped with 2 sets of metal brushe one for each direction of rotation. Th levers for controlling these brushes may b noted (National Carbon Co. phot

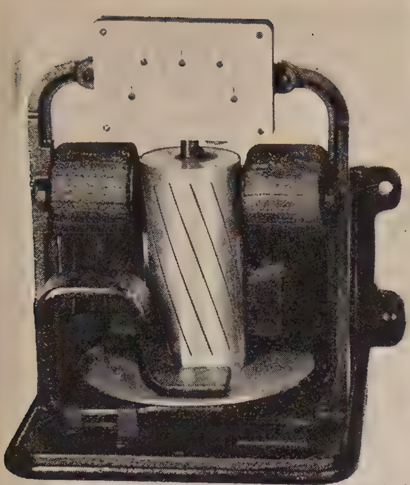


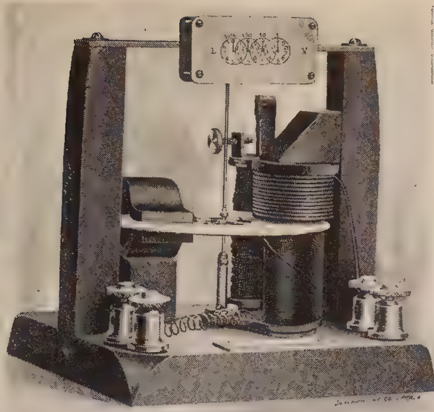
Tesla induction motors—the one on the right, with a 3-in. rotor, being a ½-hp machine. The fan blades are indicative of one of the first widespread applications of induction motors
(Westinghouse photo



A modern 6,000-hp induction motor built for steel mill service
(Photo courtesy Allis-Chalmers Co. and National Carbon Co.)

Early Electrical Instruments

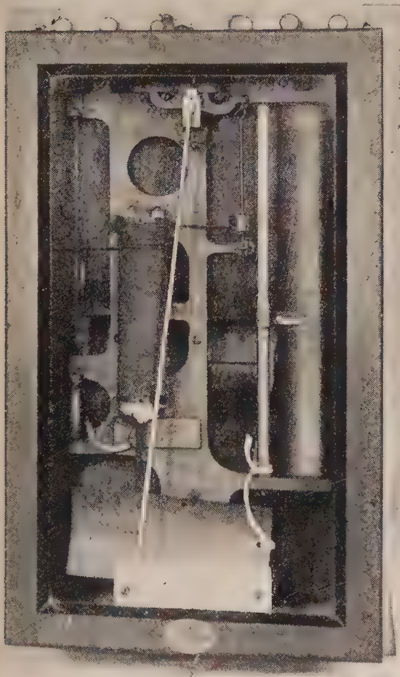


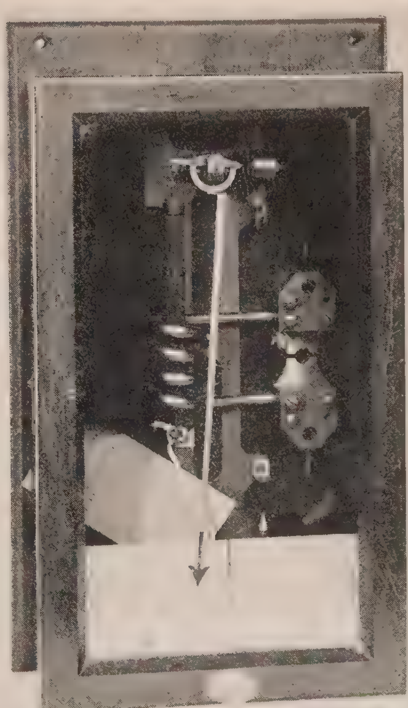


(Above) An a-c watthour meter built in 1892 utilizing a single disk for both driving and damping
(Duncan Electric Mfg. Co. photo)

(Left above) Original Gutmann watthour meter with a cylindrical armature, built in 1899
(Sangamo Elec. Co. photo)

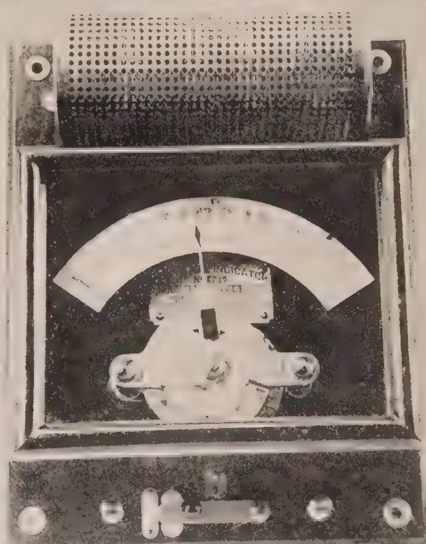
(Right) Testing the insulation resistance of a trunk line telephone cable with a "megger" (1914). The test man is E. C. Barrett (A'27) now general plant supervisor of the Chesapeake and Potomac Telephone Company of Baltimore City
(James G. Biddle Co. photo)





(Above and right) Switchboard voltmeter and ammeter used on a-c systems about 1893
(Westinghouse photo)

(Below) Cardew hot wire voltmeter. These odd looking instruments, the first type used for alternating current, depended upon the expansion of 6 ft of resistance wire as a measure of current, and hence voltage; they had a large current consumption ($^1/_2$ amp), were slow in response, and inconvenient in form
(Westinghouse photo)



(Above) An early type of indicating instrument (1895)
(General Electric photo)

The Evolution of Electrical Engineering

By Dugald C. Jackson, President A.I.E.E. 1910–11

Many colorful personal reminiscences of the exhibit and personalities involved in the 1884 International Electrical Exhibition and related "Conference of Electricians" are given here by Professor Jackson. With this background as an indication of the state of electrical engineering education in 1884, the author outlines its rapid development, emphasizes the strength imparted to it through its early and continued close association with the fundamental sciences, and, looking to the future, sounds something of a challenge to the modern era and modern attitude.

THE YEAR 1884 was significant and auspicious for the American Institute of Electrical Engineers. In that year the Institute was founded. Also, in that year it demonstrated the coöperative spirit possessed in the field of electrical engineering, a spirit which the Institute has maintained untarnished. As a consequence of a circular letter issued in April 1884, followed by a preliminary organization meeting April 15 and an election of officers on May 13, all in New York City, the first formal meeting of the A.I.E.E. for presentation of papers was held at Philadelphia on October 7 and 8 as guest of the then already 60-year-old and distinguished Franklin Institute. The Franklin Institute provided rooms for headquarters and meetings of the A.I.E.E. which were in association with the International Electrical Exhibition then being held.

That exhibition opened September 2 and continued until October 11. It served as inspiration and stimulus for an electrical conference of some official weight as well as for the A.I.E.E. meeting of October 7 and 8. I then was an undergraduate in civil engineering at Pennsylvania State College and spent the summer vacation of 1884 as assistant to William Stanley at Pittsburgh with very little compensation, but with the understanding that I should be sent (with expenses paid) to the Electrical Exhibition in the autumn as an employee of the Stanley Exhibit. Stanley was the central figure in the then new electric light department of the Union Switch and Signal Company which department later became the Westinghouse Electric Company. George Westinghouse, then 38 years of age and already of international distinction through railroad air brake and other inventions, was the leading spirit in both these companies. He was awarded the Edison Medal by the A.I.E.E. in 1911 for his "connection with the development of the alternating current system of electric light and power." He was the third of the great series of Edison Medalists.

International Electrical Exhibition of 1884

The electrical exhibition and the "conference of electricians" brought together a group of men whom we now see as the fathers of electrical engineering. These men were mostl Americans who were fron 5 to 20 years older than was. They impressed m more youthful imaginatio with their finished accom plishments and maturity A half dozen years dis parity in age, when the ob server is a youthful under graduate in a fresh wate college, magnifies like convex lens as one look objectively at maturity My tastes were toward th lighting and power aspect of the infant electrical in dustries. Consequently my attraction was towar such as Edison, Thomson, Weston Brush, Sprague, Van Depoele, an Stanley. Readers may need an ex planation of the absence of a numbe of other names. The causes are mani fold. For example, my tastes did no lead me to explore exactingly th exhibits in telegraphy and telephony Also, for example, Tesla at the age o 27 had only arrived in the Unite States; Lamme was a freshman i college; W. L. R. Emmett had re signed from the Navy, but had no yet entered engineering; Steinmetz, 19 years of ag in 1884, did not come to America until 1889; an so on. I do not remember that E. A. Sperry ha an exhibit at the exhibition. If he did, it was m misfortune not to meet him at that time.

The purposes of this paper do not admit of genera reminiscences of that exhibition or its exhibitors an comments on the large number of exhibits must b omitted; but comments regarding certain of th leading men and their exhibits are of service here fo showing the then state of electrical engineerin education.

William Stanley (Edison Medalist in 1912) wa 26 years old in 1884. He was co-inventor of in candescent lamps made of carbonized silk thread which had been soaked in a sugar solution an baked. He was an active experimenter in the con struction of dynamos and one who was deeply imbue with Ayrton's view that a generator and a moto should have contrasting electromagnetic qualitie but his experiments did not seem to support th view, which gave us some food for thought. It wa a year or more later that Mordey published his brie communication pointing out that the electromagneti structure for the best direct-current motor is th same as that for the best direct-current generato which perhaps should have been recognized earlie

from the already known reversibility of the machines. Stanley's distinguished career as an inventor in the alternating current field was started with the support of Mr. Westinghouse in the years immediately succeeding 1884.

I became acquainted with O. B. Shallenberger, perhaps through Frank J. Sprague. Shallenberger, who was 5 years my senior in age, had completed his studies at the United States Naval Academy and had made up his mind, following the example of Sprague, to leave the Navy and join the ranks of the electrical industries. We spent many hours together, when I was off duty, hanging over the railings surrounding the various exhibits and discussing our ignorance of their qualities. He introduced me to Lieutenant Bradley A. Fiske, then a Naval Lieutenant, writer of books on electricity and magnetism, teacher of electricity and magnetism at the Naval Academy, and in Philadelphia as a member of the "conference of electricians," but later a rear-admiral distinguished for the invention of numerous electrical and other devices of value in the Navy.

In return, I introduced Shallenberger to Stanley, who was seeking an assistant, as I was returning to college after the close of the Exhibition. Shallenberger fittingly became a leading factor in the technical work of the Westinghouse Electric Company until his death in 1898 cut off his career of research and invention.

Sprague (President of the A.I.E.E. in 1892–93, Edison Medalist in 1910) exhibited several of his inventions and frequently was a personal attendant at his exhibit where he extolled with emphasis and fascinating enthusiasm his self-regulating, constant-speed, direct-current motor, in which the constancy of speed as the load varied was secured by a differential series winding on the field magnet. It was in this year that the Sprague Electric Railway and Motor Company was established and Sprague at the age of 27 was fully launched on his great career of invention and promotion in the electric traction and associated fields. Electrical Engineering owes a deep debt to the American Navy for having relinquished Sprague from its service, so that he could carry on in our field.

Thomas A. Edison's personal exhibit, in charge of Wm. J. Hammer, commanded deep attention because of its manifestation of the origins and development of those many detailed devices relating to the distribution and control of electricity which contributed a large part to the success of Edison's pioneer constant voltage system for the distribution of electric power. Many other devices also were shown. Notable among these was the 3-terminal bulb which exhibited the fundamental effect (then dubbed "Edison effect") of our now much used 3-terminal vacuum tubes, but which Edison did not follow up, apparently because of his absorption in his other developments. His personal exhibit was not the only one disclosing the results of Edison's work, for several of the manufacturing companies established for promoting the use of his inventions in the electric lighting art exhibited a striking array of underground tubes, incandescent lamps, and electric machines. The Edison "Jumbo" dynamo of, according to our present ideas of rating, about 100 kilowatts capacity (direct connected to a "high speed" steam engine) was the generator of largest capacity in the exhibition. I several times caught myself hanging over the rail in front of the machine and speculating on why its field cores were made so long and thin, with several in parallel joining between the yoke and each pole piece. It was told that a large magnetic moment was needed for the field magnets and that this was an economical construction for securing that result. The reason sounded pat, but was not convincing when one compared the jumbo machine with the excellence of operation and compactness of design of the Weston dynamos nearby. I did not then know that Dr. John Hopkinson already had stated the desirability in electromagnetic machines of short magnetic circuits of large cross sections. However, the greatness of Edison's contributions to the development of electrical engineering was already established at even that early date.

Edward Weston (President of A.I.E.E. in 1888–89, A.I.E.E. Lamme Medalist in 1932) and the United States Electric Lighting Company had dynamos and lighting facilities on exhibit that were unrivalled in the combination of rational character of design and excellence of workmanship. This was before Dr. Weston set out on his productive career as designer, inventor, and manufacturer of refined portable electrical measuring instruments, followed by equally refined switchboard instruments; but his dynamos manifested the same clearness of structural lines that have always characterized the construction of the Weston instruments. The magnetic circuits of the dynamos were moderate in length and of large cross section, the armature resistances were low and the resistances of the shunt field windings were notably high. The qualities of these Weston dynamos of 1884 prepared me to accept unreservedly the statement made by Dr. Weston at a conference at the World's Fair at Chicago in 1893 that he used a definite empirical formula in designing the field magnets of his machines for some years before Gisbert Kapp made known his empirical formula for the magnetic circuit and Dr. John Hopkinson published his notable analysis of the magnetic circuit accompanied by the rational formula.

The exhibit of the Brush Electric Company left no very vivid impression on me. It undertook to portray the usefulness of electric motors and electric lighting in the home and factory as far as such usefulness then existed, in addition to arc lighting for exterior areas. But the exhibit seemed impersonal and lacking in verve, probably because it lacked the stimulating presence of an enthusiastic inventor, since Charles F. Brush (Edison Medalist in 1913) was seldom in attendance.

Of all the exhibits except that of Weston, the one maintained by the Thomson-Houston Company of which Prof. Elihu Thomson was the leading scientific figure and leading inventor, has left on me the liveliest memory. It was impressive because of its comprehensiveness in display of commercial apparatus and because of its collection of Professor

Thomson's models and experimental apparatus set up with the various devices arranged for demonstration. In the first or commercial aspect it did not rival the display of constructions arising from Edison's inventions, but in the second it enjoyed the frequent attendance of Professor Thomson (President of the A.I.E.E. in 1889–90, Edison Medalist in 1909) who was incomparable as a lecturer regarding his operative apparatus and as a demonstrator of his scientific experiments. I still retain a vivid picture of Thomson, then 31 years of age, standing in the midst of a demonstration of certain scientific experiments which he was carrying on. He always attracted an appreciative gallery on account of his enthusiasm. His was a scientifically trained mind that commanded great interest.

Of Van Depoele my relations at the exhibition in 1884 were perhaps more personal than with the others mentioned. We not infrequently sat together at luncheon in a little restaurant. He was more than twice my age, but his kindliness of attitude toward his junior and his resourceful spirit endeared him to me. I remember little regarding Van Depoele's exhibit. He was a man without deep learning in science, but his quickness of imagination and his facility in empirically adapting knowledge (gained in his long experience) to improving defective devices or overcoming faulty operation were incomparable. The latter qualities made him a great inventor in spite of absence of scientific learning.

The Meagreness of Electrical Science in 1884

Although the magnetic circuit designs (previously referred to) of Edison and his associates in 1884 were faulty even considering the then state of science, they were far more rational than those of inventors whose erroneous conceptions of the magnetic circuit led to many bizarre designs for dynamos that were shown at the exhibition, but which I will not here describe. Rational scientific efforts in designing electrical machines, systems of electrical distribution, electric lamps, and electrical instruments were still dependent on the individuals in 1884, and had not yet become broadly professional practices. The meagreness of knowledge of magnetic and electric phenomena in 1884 is illustrated further by the armature cores (made of cast iron discs) of the Stanley direct-current dynamos in the exhibit, and also by the paper at the Philadelphia meeting of the American Institute of Electrical Engineers by Prof. C. F. Brackett of Princeton University, entitled "Experimental Method of Testing a Dynamo Machine," and by a lecture on the magnetic circuit by Professor Henry A. Rowland of Johns Hopkins University. It was Professor Rowland's series of publications begun in 1873 when he was 25 years of age and an Instructor in Physics at Rensselaer Polytechnic Institute that gave the first experimental disclosure of the relations of magnetic permeability to magnetizing force in iron and other metals. The phenomenon of magnetic hysteresis and its effects were not recognized until 1885 when J. A. Ewing, now Sir James Ewing of Cambridge (England) but then of University College, Dundee, published the paper disclosing his notable experimental work.

A further illustration of the youthfulness of electrical science in those days may be drawn from the provisions adopted to prevent fire hazard from the electric circuits in the various exhibits and from the circuits used for the general lighting of the exhibition building. E. J. Houston (President of A.I.E.E. in 1893–95) was "electrician" of the exhibition and Carl Hering (President of A.I.E.E. in 1900–01) was "assistant electrician." Professor Houston was chairman of a "committee for the installation of electrical apparatus." The report of the committee on exhibitions of the Franklin Institute submitted after this exhibition was over says of the duties of the "electrician" and the "assistant electrician": "The circuits [i. e., within the exhibition building and annex] were tested daily for 'contacts' or 'grounds' by Professor Houston, or by his assistant Mr. Hering, and all causes of danger removed before the current was permitted in them." I made my first acquaintance with Hering as he daily made his rounds with a hand magneto with which he tested the various circuits of the exhibits and also the general circuits of the Exhibition for "grounds."

Development of Electrical Engineering Curricula

The foregoing reminiscences will bring to the reader's imagination the state of electrical engineering education in 1884 in a more lively manner than would likely be secured by a bare recitation of the then state of science in this educational field. The reminiscences also outline the background for a picture showing the vigor and velocity of growth of electrical engineering during the 50 years since 1884, which background may be used by any one who today looks about him to secure the impressions from which to paint in the foreground of the picture. Of the exhibitors named in the preceding pages those now dead have left behind legacies of internationally used conveniences that their discoveries and inventions contribute to our modes of life. Sprague at 77 years of age, Thomson at 81, and Weston at 84 still remain to receive the continued plaudits fitting to their great achievements. Their lives measure the span of growth of the expansive and vigorous structure of electrical engineering as we now perceive it. That structure still exhibits a vitality and velocity of growth equalling that of its preceding years, and this must be part of one's vision when planning electrical engineering education.

The chronological sequence for the development of electrical engineering curricula in physics departments of American universities shows that formal education in electrical engineering was well under way by 1890. Obviously, professors of physics during the decade beginning with 1880 found their imaginations inflamed by the intriguing possibilities of electromagnetic machines applied to useful purposes. Consequently subjects relating to the theory and the applications of electricity and magnetism appeared among the emphasized subjects of instruction in physics departments of many univer-

sities. This was the kind of educational environment from which many who became distinguished electrical engineers emerged between 1880 and 1890. Such, for illustration, were: John W. Lieb (President of the A.I.E.E. in 1904–05, Edison Medalist in 1923), Stevens Institute of Technology, Class of 1880; E. W. Rice, Jr. (President of the A.I.E.E. in 1917–18, Edison Medalist in 1932) pupil of Professor Elihu Thomson at Central High School, Philadelphia, Class of 1880; Chas. L. Edgar, Rutgers College, 1882; Chas. F. Scott (President of the A.I.E.E. in 1902–03, Edison Medalist in 1929), Ohio State University 1885; C. C. Chesney (President of the A.I.E.E. in 1926–27, Edison Medalist in 1922), Pennsylvania State College, 1885; and so on.

The natural course of development led to the formulation of 4-year curricula in electrical engineering more or less correspondent to the curricula at that time extant in other branches of engineering, but more heavily charged with the temper of physics and directed by the physics professors. The first such course was proposed and organized in the autumn of 1882 by Prof. Charles R. Cross, Head of the Department of Physics in the Massachusetts Institute of Technology. A similar proposal was made and a course organized a few months later, and apparently quite independently of Professor Cross's proposal, by Prof. Wm. A. Anthony, Head of the Department of Physics at Cornell University. Graduates from each of these pioneer courses in electrical engineering secured bachelor's degrees in 1885. It obviously would be undesirable to make here a résumé of the origin and development of all the more than 150 formal electrical engineering courses now in being in the United States, or even of all of the more notable ones. Each of those to which I later refer is chosen for some historical or geographical reason. I beg that no alumnus may feel offended in case his Alma Mater is not referred to in my further list of those commented on.

A tidal wave in the formal establishment of electrical engineering curricula in the universities and colleges, mostly associated with departments of physics, flowed in 1887. It affected the country at large, as is witnessed by Pennsylvania State College, Case School of Applied Science, Purdue University, University of Minnesota, University of Kansas. During the succeeding 5 years many additional curricula associated with physics departments were established from the East to the West. Another turn came in 1891 when the University of Wisconsin proposed to establish an electrical engineering curriculum. At that time I was consulted on the question of whether it would be better to place the curriculum under the administration of the physics department or to establish a definite department of electrical engineering and make it coördinate with departments of civil engineering and mechanical engineering. At the same time I was invited to leave my employment with the Edison General Electric Company in active engineering planning, estimating and construction and to occupy the first professorship of electrical engineering in that University. On the ground that the content is engineering (i. e., applied science, or perhaps it is better to express it as science and its applications) rather than purely science, my advice was to establish the department of electrical engineering coördinate with the other departments of engineering. This view was adopted and I believe that to be the first department of electrical engineering to be initially so established. The view has proved to be valid and nearly all electrical engineering curricula in the colleges and universities of this country are now related to definite departments of electrical engineering.

That the view had begun to receive recognition

A Group of Past-Presidents in Attendance at the Chicago Convention, June 29, 1911

Those in the group (with periods of presidency indicated in parentheses) are as follows: back row, left to right: Gano Dunn (1911–12), Dugald C. Jackson (1910–11), Louis A. Ferguson (1908–09), Schuyler S. Wheeler (1905–06), John W. Lieb (1904–05), and Bion J. Arnold (1903–04); front row, left to right: Francis B. Crocker (1897–98), T. Commerford Martin (1887–88), Frank J. Sprague (1892–93), and Charles P. Steinmetz (1901–02). Of the 10 past-presidents in the group, 5 still are living and 3 have contributed articles to this anniversary issue

(Photo courtesy Past-President Sprague)

before 1891 is shown by the fact that the administration of the course in electrical engineering at Cornell University had been transferred from the physics department to Sibley College of Engineering before 1890, but it was several years later before such transfers became general. The oldest of the pioneer courses in electrical engineering was retained in the physics department at the Massachusetts Institute of Technology until 1902 when a department of electrical engineering was established and Louis Duncan (President of the A.I.E.E. in 1895–97) was appointed professor of electrical engineering and placed in charge of the department.

The number of men of influence in electrical engineering industry who are alumni of educational institutions in which they pursued undergraduate electrical engineering courses maintained by definite departments of electrical engineering aggregates many thousands; and their service to the nation through their contributions of means which provide convenience in life to populations numbered by tens of millions is beyond calculation. Manifestly, the electrical engineering departments, established in the engineering schools as coördinates with the departments dealing individually with the other and older major branches of engineering, have produced an influence, as departments, that is vastly greater than the effect produced solely on their individual pupils, large though the latter is. However, we owe a debt to the physicists. The remarkably large influence on American engineering industries that has been exerted by electrical engineering I believe arises partially from the early relations from which we have profited. Our modes of thought, our units of measurement, even our processes of education sprang from the science of physics (fortified by mathematics) and from physicists. The precise measurements and controlled experiments introduced into our field from the field of physics gave a tremendous impetus to rational and accurate engineering calculations and also left a scientific impress on electrical engineering teaching. As a consequence, our educational processes and our engineering practice possess a notably large portion of rational application of the underlying science. In this respect we are paralleled by the later developed branches of chemical engineering and aeronautical engineering. Civil engineering, mining engineering, and mechanical engineering, as the older major branches, arising (as they did) before the sciences were adequately expanded to provide a rational foundation for engineering practice, still maintain a large proportion of empiricism in their college curricula. I am of the opinion that the civil engineering and mechanical engineering fields would be benefited were the engineering schools to rigorously prune the curricula in those branches and then inject into them a more rigorous and scientific aspect.

A.I.E.E and Electrical Engineering Education

Organized, as it was, at a date when the science underlying electrical engineering was expanding rapidly, one might assume that the American Institute of Electrical Engineers would lend its ear and its voice to the problems of electrical engineering education. Its first group of officers, among 6 vice-presidents, included one whose principal occupation was in education and also included 2 such among 12 managers. One vice-president (Alexander Graham Bell) and one manager (Elisha Gray) in this group also had previously been teachers, but they had been drawn away from that occupation by the fascinations of full time spent in discovery and invention. A similar proportion of men with their principal occupation in education was maintained among the elected officers for some years. Likewise the sixth president was drawn from education, and this example has been followed many times in the succeeding years. Nevertheless, it was 8 years after the first meeting (namely, in 1892) that the Institute listened to a paper definitely directed to electrical engineering education. Indeed, there were then 2 papers presented at the same session—one prepared by R. B. Owens, professor of electrical engineering at the University of Nebraska, and the other by myself, then located at the University of Wisconsin. Ralph W. Pope, then secretary of the Institute, was dubious about the interest that could be aroused for such papers, but their presentation was followed by an animated and well couched discussion which would occupy as much space as the papers themselves if printed in the same type.

The ice was broken and the problems of formal education for electrical engineers have since come into our proceedings again and again. Ten years later (in 1902) President Steinmetz built the theme of his presidential address at the Great Barrington meeting largely on electrical engineering education; and four papers concerning the subject were presented by competent men at the same meeting. A copious discussion was aroused.

The Character and Testing of Electrical Engineering Education

The following year (1903) the Institute held a joint meeting with the Society for the Promotion of Engineering Education, with the result that 7 papers came into the Transactions along with considerable discussion. At this meeting I again appeared with a paper on electrical engineering education expressing opinions gained by 12 years of experience at the University of Wisconsin where I was having a grand time linking mathematical physics and experimental investigation of a rigorous character with electrical engineering education, recognizing that only by personal experience in grappling with the unknown can students truly gain knowledge and learn its significance in self-reliant use. In that paper I expressed a wish to be delivered from judgment upon the success of my efforts unless such judgment was guided by the attainments reached by my students in a decade to a quarter of a century succeeding graduation from their electrical engineering college course. C. F. Scott (then president of the Institute) expressed some doubt regarding the propriety of such delay in reaching final conclusions about the individual men. He has since

that time become a professor of consequence and a Lamme Medalist of the Society for the Promotion of Engineering Education. I infer that as a consequence of his later experience he now does not disagree with my view, while both of us duly recognize that delay in reaching final conclusions regarding educational efforts should not connote absence of constant scrutiny and comparison of processes that are associated with efforts at pedagogical improvement year by year. Testing the product of engineering education immediately (as one would a dynamo before it leaves the shop door) is serviceable to guide improvements, but is not significant for showing final results. This is because the results in each individual of proper professional education grow richer and more desirable by aging, whereas the results of mediocre types of such education are less influenced by the aging process.

Fifteen years of observation and experience at the University of Wisconsin convinced me that making research an integral part of electrical engineering education is of primary value. I therefore took this tenet as a primary one upon going to the electrical engineering department at M.I.T. in 1907, and it has been there maintained with increased emphasis to the present time. At various times heretofore I have expressed the argument regarding this and need not repeat it here.* Continued observation and experience unqualifiedly confirm the correctness of the method.

Importance of A.I.E.E. Committee on Education

For a further period of years after 1903, papers on electrical engineering education frequently entered the proceedings of the A.I.E.E., and the activity was all serviceable and suggestive. Of recent years, however, the activity apparently has lulled. Some excellent papers have been produced, but they have elicited little comment compared with their value. Why is this? I will endeavor to give an answer to this query; but first I will state unconditionally that the American Institute of Electrical Engineers has excellently proved its continuing official interest in electrical engineering education in various ways, the most notable of which are its coöperation with the board of investigation and coördination set up by the Society for the Promotion of Engineering Education to study both the pedagogical and the human needs of engineering education, and its support of the program proposed by the Engineers' Council for Professional Development. It is to be earnestly hoped that this attitude will be maintained, since the continued high standing of electrical engineering depends partially on this coöperation in education. The student conventions and prizes for student papers also must be recognized as an important element in educational coöperation by the Institute in addition to the maintenance of Student Branches, and likewise must be so recognized the prize presentation of papers by younger members now being fostered in several Section areas.

* For example, see The Function of Research in Engineering Education, an address before the Society for the Promotion of Engineering Education, June 1931, published in *Science*, Aug. 21, 1931, Vol. 74, pp. 183–187, and in *Journal of Engineering Education*, Jan. 1932, Vol. XXII, pp. 348–355.

Now to reply to the query of the preceding paragraph: The answer, it seems to me, is to the effect that a large proportion of our members forget that the Institute (including themselves individually) has a responsibility for maintaining the high level of intelligence and character in the electrical engineering field, and they also forget that mutual consideration and analysis of the problems of electrical engineering education are potent means toward securing the desired end. Therefore they are not impelled into discussions of papers on education. We have an admirable attitude in the concrete matter of encouragement for students, but take less interest in the pedagogical structure of electrical engineering education.

The board of investigation and coördination appointed by the Society for the Promotion of Engineering Education carried out its duties in the spirit of rigorous inquiry, as far as the yet rather undeveloped science of pedagogy admits of rigor, and its reports give data and carefully drawn opinions and (where the data are competent to support conclusions) statements of conclusions. It is this character which has given their wide influence to the reports of this board. Likewise, the expectation that the Engineers' Council for Professional Development will follow the scientist's route of investigating conditions before arriving at conclusions, and expressing the latter only where conclusions are warranted by the data, is a feature that supports the confidence which is expressed in that representative organization.

A corresponding attitude assumed by the A.I.E.E. committee on education might reëstablish the former interest of the individual Institute members in its subject. This is a technical committee of the A.I.E.E. and, in addition to its duty of arranging for the presentation and discussion of papers before the Institute, it is commanded by the by-laws to present an annual report at the summer convention which shall include "a brief résumé of the progress of the art in the particular field" within the scope of the committee, in order that these reports (among others) "may become recognized as authoritative sources of information on the history of electrical engineering development." There is a real opportunity here for this committee, which would raise it from the conventional level of solely a seeker after papers for the Transactions to the level of a stimulator and producer of acclaimed papers of creative type. Effectiveness in the suggested field would call for some degree of coöperation with certain committees of the Engineering Foundation, the Engineers' Council for Professional Development, the Society for the Promotion of Engineering Education, and perhaps of other organizations, in order that the annual reports on the progress of the art of electrical engineering education should be of significant service.

My suggestion may involve work which no committee will undertake in the field, but the "educational series" now in course of publication in Electrical Engineering under the sponsorship of the committee provides a grand background for the production of influential annual reports. The conventional status heretofore sometimes voluntarily

assumed by the committee prevents it at such times from giving effective service to the Institute in the field of electrical engineering education. The teachers themselves are not faultless. Much that is put forward as appropriate for educational processes analyzes into poorly marshalled personal opinions with insufficient backing of exact observation or analyzed experience. The reports suggested for our committee on education would produce a stimulus for the teachers to do closer thinking regarding education in the broad, and regarding the content that should make up an electrical engineering curriculum as well as regarding the processes of teaching the curriculum subjects. One of our difficulties in the engineering schools lies in the fact that it is commonly forgotten that the teachers, as a rule, must not be cloistered men, and that men needed for leadership in engineering education are ones who are practiced and, if possible, great in two professions—the profession of engineering and the profession of teaching. We do not always make suitable provisions in the way of ultimate available salary and freedom in the choice of work to secure such men, on whom we might rely for clear thinking at all times.

A Responsibility of the Engineering Schools

Within the engineering schools, we have the problem of securing well founded and thoughtful criticisms of our practices associated with suggestions for improvement. Many of the individual suggestions that we receive are founded specifically on some one's memory of his own undergraduate days, and exhibit no conception of changes of curriculum and procedure that have occurred in the intervening interval. Efforts at improvement founded on such proposals are not scientific and usually are untenable. We have many articles of reform to be considered, but none should be irrevocably acted upon until conclusions can be reached as a consequence of sound reasoning on the data of controlled experiment, or of cautiously formulated deductive reasoning when data cannot be secured.

For example, the question of length of curriculum required to produce the best aggregate results is again to the fore. The proponents of a 5-year or 6-year formal curriculum argue staunchly for their own favorite idea, using *a priori* reasoning supported on often repeated grounds of an inconclusive nature. As far as I know, they have not gathered data capable of indicating whether or not a *larger proportion* of graduates who have pursued the longer formal curricula have come to distinction than of graduates who have pursued curricula of the usual 4 years' length, which data (if practicable to accumulate) might have some conclusive weight when fairly interpreted. Nor have they gathered corresponding data capable of indicating the proportional achievements of graduates who have followed the longer formal curricula compared with graduates who have pursued usual 4-year curricula followed by one or more years of rigorous graduate professional study in each individual's chosen branch of engineering. My own observation leads me to a tentative conclusion that the longer formal curricula have not produced a larger proportion of eminent men or a larger proportion of happy men, but that such men probably arise in larger proportion from rigorous graduate study of highly advanced professional type which is of the students own choosing, when the longer period of study is embraced. If this inference is correct, then the formal longer college curriculum ought not to be made the general basis of electrical engineering education, but nevertheless it might become recognized as a desirable variant to maintain in a few instances. Those engineering schools which espouse the longer formal curriculum therefore may be encouraged to continue in their chosen path for the present while they gather data that may be marshalled in form to show the comparative results. In the meantime those of us who have to do by preference with 4-year undergraduate curricula where proper freedom is permitted in student selection (and in some instances also direct rigorous professional graduate study) will continue to welcome hospitably into the proper place in our undergraduate work those students who have chosen from their own incentive to secure previously a degree in arts, provided mathematical and physical science provides the main feature of the bachelor of arts course. A voluntary choice in the ordering of his own education is usually an indication of good intellectual fiber in a student, but a slavish following after fashion or habit in education usually indicates the opposite.

Another internal problem which now agitates the engineering schools relates to the proper integration of political economy into engineering education without sacrifice of any of the excellent qualities that have been secured by the integration of science into the engineering education. There is much argument in the circles of engineering education, but little outcome as yet that is definite. There is not opportunity in this article to discuss this feature adequately. I have briefly expressed my opinion in a recent vice-presidential address for the American Association for the Advancement of Science,* and elsewhere have treated the matter more fully. The matter is of great importance to electrical engineering education, and the determination of its correct treatment is a problem lying before us.

These 2 examples are sufficient to indicate that the great problems in electrical engineering education are not yet all solved. There are many important unsolved ones besides the 2 mentioned as examples. To solve some of them with an ultimate solution, we must know more fully from whence spring the peculiar advantages of engineering education, and this obviously will require further intensive investigation. Thus the pedagogical aspects, the science aspects, and the engineering-economics aspects of electrical engineering education possess jointly the absorbing fascination of a great field for exploration and experiment, as well as an important occupation in day-to-day practice. Solving the problems of electrical engineering education is a responsibility of the engineering schools but the American Institute of Electrical Engineers has its own responsibility for coöperating in manners heretofore stated.

* For example, see The Origins of Engineering, *Science*, Dec. 29, 1933, Vol. 78, pp. 589–596, cf. particularly p. 595.

The Engineer a Creator of Leisure

By William McClellan, President A.I.E.E. 1921–22

The Institute, founded at the beginning of a "new deal," now celebrates its 50th anniversary in the midst of another new deal. What of the engineer's part in today's new deal? He must go ahead as enthusiastically as ever with the creation of labor-saving devices and thus with the creation of leisure—not loafing, but a leisure to be filled by satisfying activities.

THIS YEAR we are celebrating the fiftieth anniversary of the American Institute of Electrical Engineers. This 50 years concludes the real development period of what we now call electrical engineering. As I look back over this period it seems clear, although we didn't know it then, that we were at the beginning of a new deal. Faraday, our patron saint, gave us electromagnetic induction in the '30's; but his source of electrical energy, and that of every one else for years after, was the primary battery. That was all that Morse had for the telegraph. Magneto-electric sources were used by the telephone and, on a larger scale, for lighthouse lamps and some other purposes.

Faraday had given us the powerful electromagnet, with the easy manipulation of field control, but it was many years before the commercial development of the so-called dynamo-electric machine started. At that time there were no electrical engineers. Extraordinary men originating in the shop, like Swinburne, met great scientists like Sir William Thomson, as we knew him then, to break new roads on which civilization would travel. The Centennial of 1876 at Philadelphia had little that was electric, and yet only 8 years later there were enough men in electrical engineering to bring the Institute into being. I shall attempt no story of history here, but refer you to the PROCEEDINGS of the Institute, and kindred publications, for it all.

What a splendid flowering there was. The rapidity of the development was dazzling. Designs and inventions jostled each other, and the life of any was marvelously short. The electric lamp and motor, with almost myriad forms of auxiliary and utilization devices, came on in a bewildering rush. Machines grew larger and larger. Apparatus requiring time for construction was obsolete often before it could be installed. Electrical engineers themselves marched on to greater and greater successes, and made it possible for brother engineers in other fields to go on to similar great achievements. Yes, it was a new deal, and everybody, from the lowest to the highest, reaped enormous benefits of one kind or another.

Those electrical engineers transformed home and street lighting. They replaced the old open-flame flickering gas lamps, 500 feet apart on the streets, with brilliant light units, and were not to be denied even when our gas-lighting friends struck back with the Welsbach mantel. They gave industry the electric motor for a million uses. Elevator service was transformed, and the horse car went into limbo. Underground and all forms of rapid transit railways were made possible. Power transmission and distribution systems were developed so that convenient power was at one's elbow, wherever even the smallest group of people gathered. They improved and expanded and multiplied telephone service until men could reach for a telephone as easily as they pick up a pencil, and talk to each other far apart as easily as face to face. Then came radio in its great variety. Maxwell said there were electromagnetic waves, Hertz showed them to us physically, and the electrical engineer made them serve us. So much in the space available, for the activities of the engineer in the old deal; but what about the economic and social results?

A year or so ago, in the course of an impromptu public discussion, I made the remark that "engineers are magnificent creators of unemployment." Of course, it was literally true, but that didn't prevent a host from inveighing against it. Naturally unemployment did not mean idling. We all had been using it for some time to mean "no job at customary gainful work." So later on I remade my declaration into "engineers are magnificent creators of leisure," and hastened to add that leisure did not mean loafing, but an opportunity to do things one wanted to do for pleasure or interest and not just to earn a living. Anyway, true or not, it seemed to some to put the engineer in a bad light, notwithstanding that invention and design of labor-saving equipment really had created, at least in the past, more jobs than they had abolished—millions of electrical workers for the thousands of gas-lighting men and bell-hangers, millions of jobs for factory workers and distributors of a thousand new devices, millions of telephone mechanics and operators of all sorts. The same kind of results obtained in trolley cars, rapid transit systems, and radio; and in other than purely electrical fields the same kind of activity is found. Statistics are not needed to prove the enormous difference in numbers between the livery stable men and cab and horse-car drivers, and the mechanics, garage workers, chauffeurs, and filling station men associated with the automobile. Statistics are not needed, but they prove that machines such as cranes, ditch diggers, road machines, turret lathes, and the like, which apparently threw men

out of work, really put more men to work by making possible a greater volume of construction.

No one took up the point that this increased employment was unimportant to many individuals if they suffered in a variety of ways while waiting for the new jobs to materialize and if many of the same individuals could not then qualify for the new jobs. Of course, this is inevitable. In the onrush of the crowd some are bound to be trampled on—some crushed to death. Sad as it may be, that is the price of progress; and with it all we did create leisure—we passed to the 8-hour day. Only a word more for the other results flowing to our social well-being. These may be epitomized in a few words—leisure, safety, comfort, convenience, and better living.

Has the Engineer Gone Too Far?

Came the depression with all its staggering losses, unemployment and human suffering for all types of workers. Soon was heard the cry that this engineer, this creator of leisure, had gone too far. Many of his machines ought to be scrapped. It would be better if ditches were to be dug with the pick and shovel. Millions of homes again were to be the scene of homespun activities. It would be better if everybody more or less would raise his own spinach and potatoes in his own garden. In fact, a relatively large group was ready to assert that machines, the product of engineering activities, were wrecking civilization.

In the midst of this more or less maudlin discussion, at times bordering on asininity, events conspired to show that the engineer had some kind of a devil in him that just made him persist in his fiendish, civilization-wrecking activities. The very unemployment he had helped to bring about finally got him. Thousands of him lost their jobs. Then what did he do? Well, not being able to do construction work, with the help of his machines and with a compelling impulse not to loaf, he had to turn to working out schemes for a thousand labor-saving devices which he had not had time to develop in the midst of prosperity. A lifetime of engineering activity had made me acquainted with many engineers, young and old, who had lost their jobs. Almost invariably, when I asked these men or their friends: "What is so and so doing?" the answer was: "Oh, he's developing 'this and that.'" A little discussion showed that "this and that" was a labor-saving device or process.

The "New Deal"

And so we come to the "new deal." The outstanding features of it are employment for all and a more abundant life for all. Hours are to be shorter so as to give everybody work, and individual pay is to be higher so as to distribute better the products of industry and to create greater purchasing power. Offhand this seems all right, but soon questions crowd up for answer. The idea seems to be that the same production will be accomplished by more people and at a greater cost. Won't prices for everything go up and therefore a man's "goods wages," that is, his real wages, be less? Can the scale of living be maintained as "goods wages" get nearer and nearer to subsistence wages? Then how about all the men in the luxury industries and what will be left over in the aggregate for the capital goods industries which depend largely upon investment? It seems almost evident that this plan may reduce unemployment, at least temporarily but will not bring about recovery. It will create leisure, but will the man's "goods wages" be sufficient to provide not only a desired scale of subsistence, but also the wherewithal and the zest to enjoy the leisure, that is, live the more abundant life? And if we do not insure at least a reasonable return on the real investment involved in the production, what about the millions of people who are not producers but depend upon dividends and bond interest for a living? Finally, do not forget that taxes must be earned by these workers to provide for the expenses of government of all sorts, with its seemingly necessary millions of employees. Indeed, something more is needed than merely shortening hours and raising wages.

In my opinion, if we are to have prosperity, we must increase production to the point where there is sufficient of every kind of goods to satisfy the needs of every one. In addition, we must distribute these goods in accordance with the needs of every one. This is more easily said than done, but it is absolutely essential for permanent prosperity, and therefore for recovery. I believe our present total production is inadequate, but every one knows that even our present production is very much unbalanced among different goods. There is too little of many goods and too much of others.

When I speak of distribution, I do not speak of the mechanical means of distribution. Our means of transport may be sadly imperfect here and there, but that only means inefficiency, not a stoppage or prevention of trade. For years we have known that capital flows to where it will be paid for, but we are just learning that other goods will obey the same law. Proper distribution of goods means a proper distribution of purchasing power—proper distribution of purchasing power among wage earners of all kinds, independent workers such as farmers, white collar men, entrepreneurs, and capitalists. We have set ourselves a Herculean task. We tell ourselves in the same breath that recovery cannot come on in a hurry on wings of words, but through a time consuming and arduous reorganization of our ideas and activities.

How shall the engineer behave in this new deal? Like every other man, and especially every other professional man, he has varied responsibilities. As an engineer he has his specific responsibilities, but he is also a citizen and a member of the social community.

The Engineer's Part in the "New Deal"

As an engineer, his part is to increase production and the mechanics of distribution. He must go ahead as enthusiastically as ever with the creation

of new machines for this purpose. A labor-saving device is a boon to humanity. It enables the worker to produce his maximum of both goods and leisure. It enables us all to enjoy a more abundant life. It gives us time to express our souls in whatever way may be most satisfying to us. In all these activities the engineer is as necessary to prosperity as the moralist who teaches us the objects of living, the economist who adjusts the various factors in living, and the medical man who keeps our bodies and minds capable of living.

The engineer, however, has to remember that he is also a citizen—a social being. He then must maintain an intelligent sympathy with those who have other responsibilities than his in balancing life. He must give more thought to the far-reaching results of his specific activities. He offers the world the products of his brain and work and he must have an understanding of the specific tasks of other professional men and be responsive when they offer their products. He must understand that all men are created free and equal only in a very narrow sense. He will participate in the necessarily great process of education through which the human family continually must progress before the more abundant life can be attained. He will keep in mind what a multitude of erroneous ideas must be eradicated. He will begin to think that "dying in the saddle" is perhaps not the best ideal and that instead of men dreading the time when they would have to retire or be retired, they would be educated to look upon the "working period" of their lives as a limited period, the end of which they were looking forward to as a time when they could begin to enjoy a leisure they had earned—a leisure to be filled by satisfying activity of their own choosing.

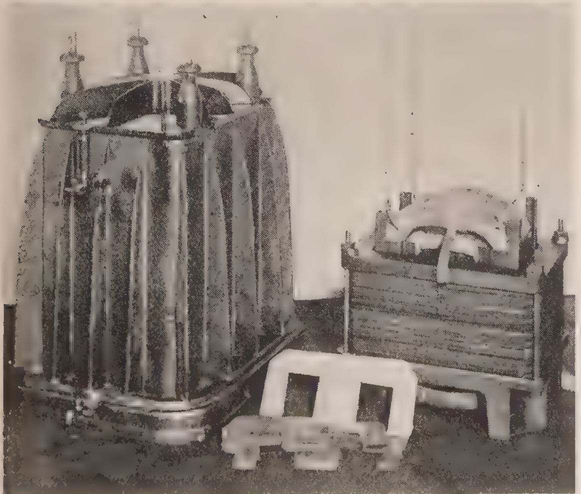
This, to my mind, is the only "new deal" worth while, and the engineer has a glorious part to play in it.

Some of the Early Transformers From Which Modern Power Systems Grew

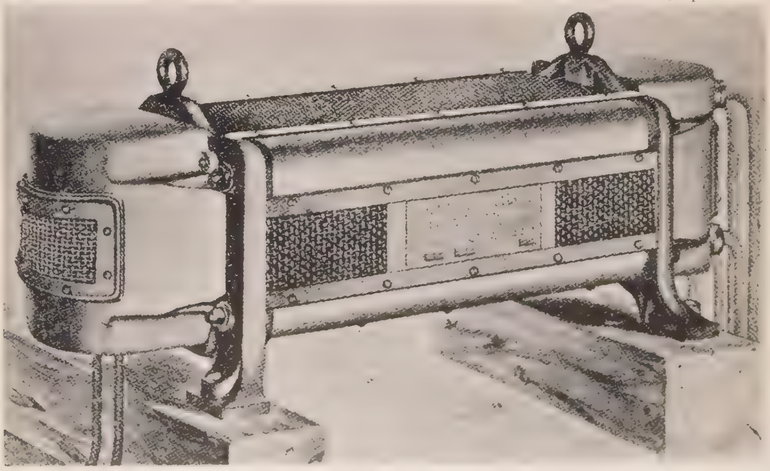
Westinghouse photo

The Gaulard-Gibbs transformer (left) and patent rights were brought to America in 1885 by George Westinghouse who set William Stanley to work at Great Barrington, Mass., to develop with his own hands the first American transformer (above). The first oil filled transformers (below, left) were developed in 1891 for the historic 10-kv line at Pomona, Calif., where they were operated 10 in series at each end of the line. One of Stanley's own 25-kva commerical models of about 1891 is shown below

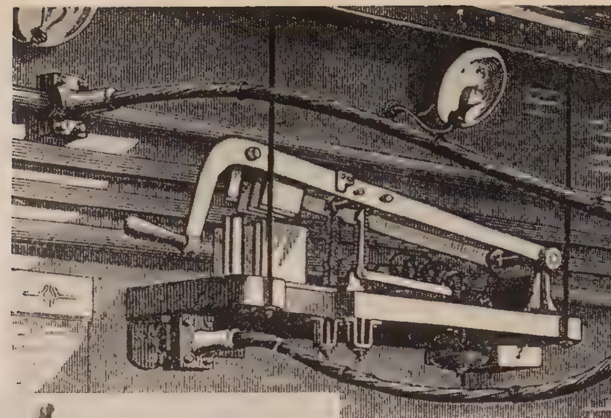
Westinghouse photos



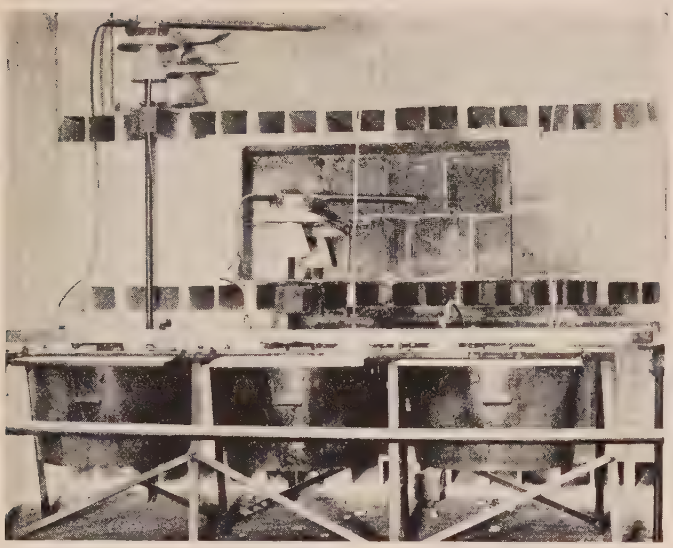
General Electric photo



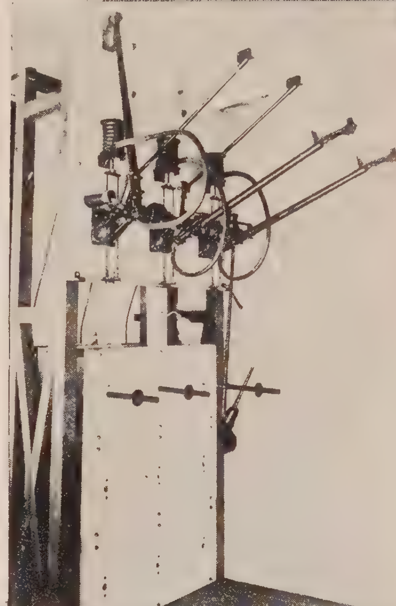
Some High Lights in the Evolution of Switchgear



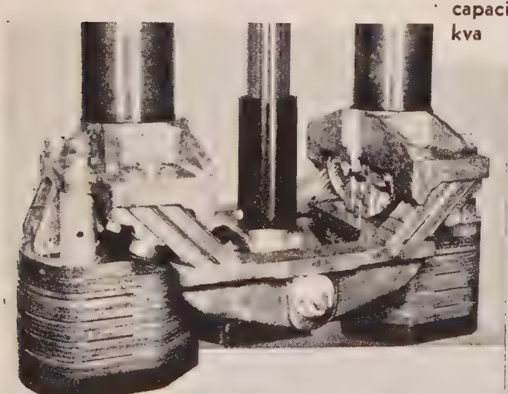
(Above) The switc that put Edison's Pear Street station, New York City, in regular commer cial operation at 3 p.m on September 4, 188
(Consolidated Gas Co. photo



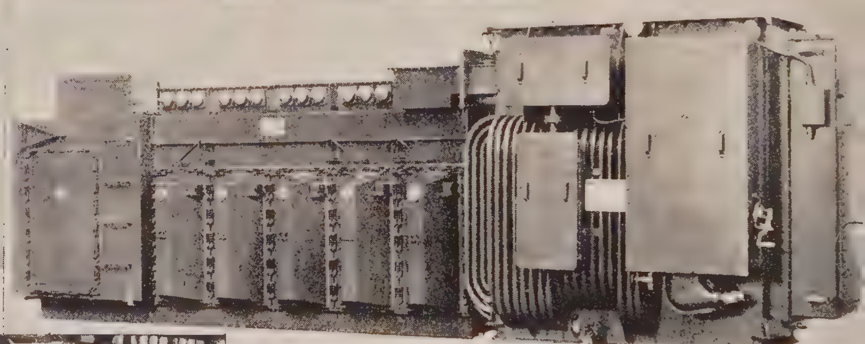
(Above) A 60-kv oil switch with fiber washtubs used for tanks; this construction is typical of many of the earliest oil switch installations
(Pacific Gas and Elec. Co. photo)



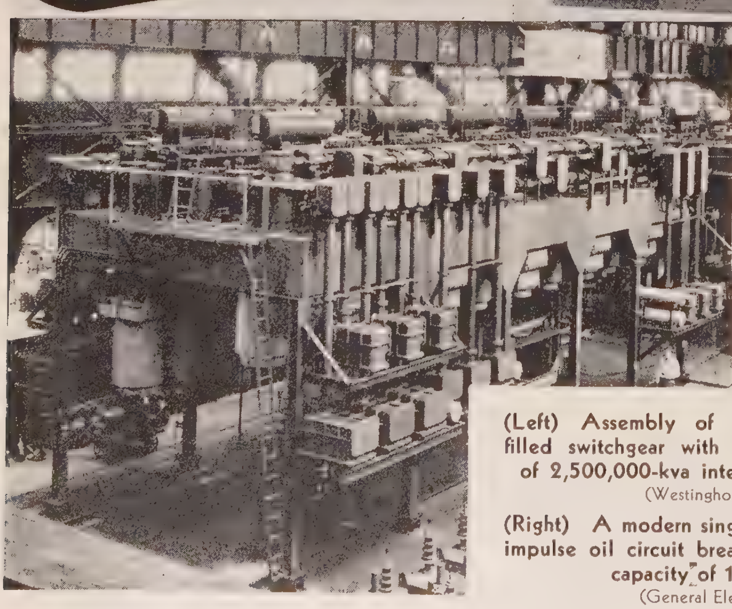
(Left) Combined disconnecting switch and expulsion fuse used before the appearance of the oi circuit breaker in 190
(General Electric photo)



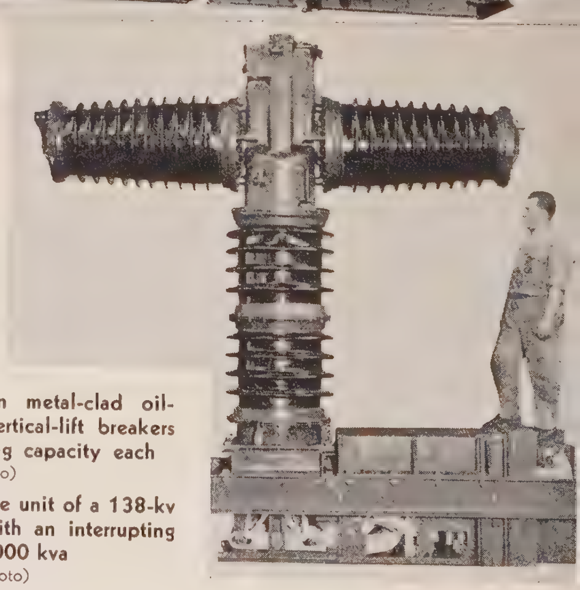
(Below left) Contacts of a modern 15-kv oil circuit breaker equipped with deionizing grids and having a rupturing capacity of 1,500,000 kva (Westinghouse photo)



(Below) A modern combination unit for primary power distribution net works, consisting of totally enclosed 1,500-kva transformer and switchgea
(General Electric photo)



(Left) Assembly of modern metal-clad oil-filled switchgear with 34 vertical-lift breakers of 2,500,000-kva interrupting capacity each
(Westinghouse photo)



(Right) A modern single-pole unit of a 138-kv impulse oil circuit breaker with an interrupting capacity of 1,500,000 kva
(General Electric photo)

Research and Engineering

By Frank B. Jewett, President A.I.E.E. 1922–23

Crediting the extent and magnitude of the technical advancement of the past half-century to engineering as the motivating force in the application of the scientific knowledge developed through the powerful facilities of the organized and coordinated research that has been developed during the latter part of the half-century just closing, Doctor Jewett believes that from the present point of view there is no reason to expect results any less striking during the next 50 years.

THE PERIOD of 50 years which has elapsed since the organization of the American Institute of Electrical Engineers as a national society in which are associated men interested in the technical phases of electrical engineering, has been a very remarkable half-century of technical advancement. Into this half-century has been crowded a greater amount of applied science, with a corresponding greater amount of collateral social change, than can be credited to many times the same interval in all preceding history.

More striking, even, than the concrete and tangible evidence of science applied to the everyday affairs of life in this half-century, is the fact that for the first time in human existence these advances on a broad front have been grounded in research employing effectively the powerful tool of the scientific method of attack in an organized undertaking of material and social advancement.

When one surveys with a critical and discriminating eye the vast changes that have taken place since the time of the Centennial Exposition it is apparent that the application of science has been the most potent factor in practically every field. The few years which intervened between the Centennial Exposition and the time in 1884 when the American Institute of Electrical Engineers was organized was a period of gestation in which the structure of the succeeding 50 years was being formed. Since there is no sharp line of demarcation in an evolutionary process such as that in which we have been involved, the year 1884 is as good a fiducial mark as any we can select. During the 50 years since that date we have witnessed not only enormous progress in the engineering arts in existence at that time, but, what is more astounding still, we have seen a whole galaxy of new arts come into being and take their places as major factors in our social structure. Many of the things that today bulk large in our daily lives and in our political and social problems were not even dreamed of at the time our Institute was organized.

Coincident with this startling development of old and new engineering arts, and essentially blood brothers of those arts, are new materials and new processes quite beyond the capacity of man to enumerate. In materials alone the new things that man, in his understanding of and control over the forces of science, has produced in the past 50 years compare very favorably with all that man and nature had accomplished previously.

Of the social and political consequences of these revolutionary changes in the physical instruments that we employ in our daily vocations and avocations, volumes have been and can be written. A brief summary like the present is no proper place for even an enumeration of such things. They are matters that will continue to concern society long after the physical developments that gave rise to them have ceased to be novel and come to be as commonplace as the most ancient of man's undertakings.

For our present purpose it will be sufficient simply to look back over the material achievements of the past half-century, to confine ourselves to the achievements in engineering, to select from the wide variety of those achievements a few typical examples, and to see whether a study of them gives evidence of any common motivating force. In our own particular sector, electrical communication, electric illumination, electric power generation, transmission and utilization, and the whole gamut of minor usages of electricity, were scarcely more than embryonic things in 1884. Essentially all that we now have, except some great discoveries like those of Faraday, Henry, Kelvin, and their contemporaries, is the result of man's activity in the past 5 decades.

Engineering the Common Factor

When we turn to other fields of applied science we find that in 1884 there was no internal combustion engine worthy to be called a tool of marked utility, and hence no automotive industry and no airplanes. There was no steam turbine and steam, though already an enormous source of mechanical power, still was generated and employed inefficiently in relatively small units by machines that were essentially kin to the things evolved by Watt. The chemical industry, though very ancient in human history, was in 1884 still an industry dealing with simple processes, largely inorganic in nature and, as compared with the things of today, with a relatively limited list of material. There was then no photographic industry that could be measured by any

such yardstick as we now employ, and the ceramic and paper industries, vast though they had become, were still not very far removed from their progenitors of an ancient time. Agriculture, the most important of all man's undertakings, was, except for the advent of a few labor saving machines, still an art governed solely by the transmitted traditions of preceding generations, devoid of real understanding of soil chemistry or mechanics, of the possibilities of producing new species at will, of disease and insect control, and quite unaware of the vast extension of markets for perishable products obtainable through refrigeration. The number of examples of which the foregoing are but samples could be extended almost without limit.

That such astounding changes in so short a period as 50 years could have come about in so many diverse fields can hardly be attributed to chance. Nor is it easy to assume that the things that have happened could result merely from a general intellectual awakening in which the several parts were unconnected. The very magnitude and diversity of the results obtained in fields widely separated and essentially unrelated bespeak the presence of something common to them all. When we come to trace back in them the current of their development we find that in every case it leads us to a point on the periphery of the same spring. That spring is the scientific method and scientific technique applied through coördinated and organized research, modified in each case merely to fit the peculiar conditions of the particular industry involved.

Viewed in a broad rather than in a narrow sense, the application of science in the various examples just noted and in all others of a similar kind, is engineering. That it may not and frequently does not have to do with structures or the operation of physical things involving power in the commonly accepted sense does not destroy the validity of the designation. This being so, the results of an analysis of some of the examples may, I think, safely be extrapolated to all.

No better illustration of the power of the scientific method and the effectiveness of organized research in the solution of engineering problems is to be found than in the field of electrical engineering. Nor is this surprising when we remember that everything of importance concerned with applied electricity had its origin in a scientific laboratory. The one possible exception to this statement might be the application of terrestrial magnetism as an aid to navigation and surveying. Here probably the utility of the earth's magnetic field in its effect on a free moving lodestone was doubtless an accidental discovery. Even this exception, however, is of relatively minor importance.

When we come to a consideration of what is commonly thought of as the field of electrical engineering we find first a few great fundamental discoveries resulting from scientific research work on which have been pyramided industrial applications developed through enlarged application of the same methods and techniques which gave rise to the original discoveries. In the earlier years of the past half-century these developments were carried on exclusively by technically trained individuals or small groups of such individuals associated togethe to develop some particular field of prospectiv utility. As time progressed and it became eviden that industries of considerable size based on th utilization of electric energy could be developec these groups tended to coalesce into larger group better equipped with trained personnel and bette provided with experimental facilities. Coinciden with this evolution was an evolution in the universi ties and technical schools of the processes by whicl men were trained in the fundamentals and technique of the scientific method.

Coördinated Research in Electrical Industrie

By about the beginning of the present centur matters had progressed so far in the field of electrica development that the beginnings of the great indus trial research laboratories, as we now know them commenced to emerge. This process has continuec uninterruptedly until at the present time the founda tion stones of every great subdivision of the electrica industry are those of a well equipped research labora tory. From the rather fortuitous beginnings at the beginning of the century, these laboratories gradu ally have assumed the proportions of very consider able industrial machines. They are fully equippec with all the necessary scientific apparatus tha ingenuity can devise or money can buy, staffed witl specially trained men of high intellectual capacity and organized systematically to attack any problem that may arise as a result either of past experience or from the imaginative consideration of the new knowledge continually poured out from the researcl laboratories of fundamental science.

In our present day electrical industrial researcl laboratories practically nothing of importance hap pens as a result of pure chance. Likewise, sub stantially nothing of great value happens merely through the operation of the so-called inventive faculty—that comet of brilliance which by intuition bursts out of hitherto dark places. In these researcl laboratories every problem that seems worthy o consideration, whether it arises from the experience of past practice or from the promise of future values in new knowledge, is carefully analyzed and its several parts put under attack by specialists. It is from their joint, supervised, and directed efforts that we derive the proved new material from which the design engineers build their new structures.

From the great research laboratories like those o the General Electric Company, Westinghouse Elec tric & Manufacturing Company, and Bell Telephone Laboratories, have come during the past 2 or 3 decades a continuous stream of far reaching im provements in the existing electrical arts, and the radically new things that have brought about the remarkable expansion in the applications of elec tricity to communication and to generation, distribu tion, and utilization of electric power. Nor do these laboratories confine themselves simply to research and development work directly in the field of appliec electricity. Every collateral field that involves materials or methods involved in the use of elec tricity has come under attack of the trained scientific

staffs which comprise them. If we were to subtract from what we now have in the field of electrical engineering, the knowledge acquired in the research laboratories during the past 15 or 20 years, our usage of electricity would be incredibly diminished, the whole structure of industry changed, employment diminished, and the social and economic structure materially altered.

What is true as regards the contributions of scientific research in the field of applied electricity is similarly true with regard to many other industries based on science in which progress has been accomplished through application of the scientific research method.

While the history of electrical engineering during the past 50 years presents the picture of a vast modern industry that has evolved almost wholly out of the work of the research laboratory, and is a field in which future progress is entirely dependent upon a continuation of this method of attack, a similar picture is presented in practically all the other great fields of human activity involved with science. That the picture presented in the field of electrical engineering during the past 50 years is a bit more striking than many others is due partly to the fact that its entire life is substantially within that period, partly to the fact that its very existence is rooted in the results of scientific research, and partly to the magnitude to which it has attained and to the multitude of its ramifications.

Scientific Research in Other Fields

If we turn now to some of the other fields in which scientific research has played the major rôle, we find a similar picture of evolution and results, but in different settings. Take, for example, the whole automotive industry, which has been made possible by the development and perfection of the internal combustion engine. Here again substantially all that we now have is the result of scientific research work done well within the period of 50 years and all based on the results of scientific research, some few fundamental principles of which, as in the case of electricity, go back before 1884. Here, too, we see the same evolution of small research groups into larger units and finally into comprehensive research organizations staffed by specially trained men and operating as organized units to solve highly technical problems, to produce new useful information, and to find useful fields of application for the new knowledge that comes out of fundamental research institutions. Collateral with and closely allied to the research work on the automotive machine itself is the research work that has been involved in the development of liquid fuels, which are the life blood of the automotive machines. Were it not for the joint results of research activity in the automotive field and in the field of fuels, we could have no airplane industry. Without an ability to produce large power with small weight from reliable machines, flying in heavier-than-air machines would still be as much of a dream as it was in the time of Darius Green.

In passing it is interesting to note that this whole field of automotive engineering is a vivid illustration of the fact that progress through research in the field of electrical engineering is inextricably tied up with progress through research in many other fields. If we were to subtract from what we now have in the field of automotive engineering the results of research work in the field of applied electricity, the whole automotive industry would collapse. The farther we go along the road marked out by scientific research the more intimate and important do these cross connections become.

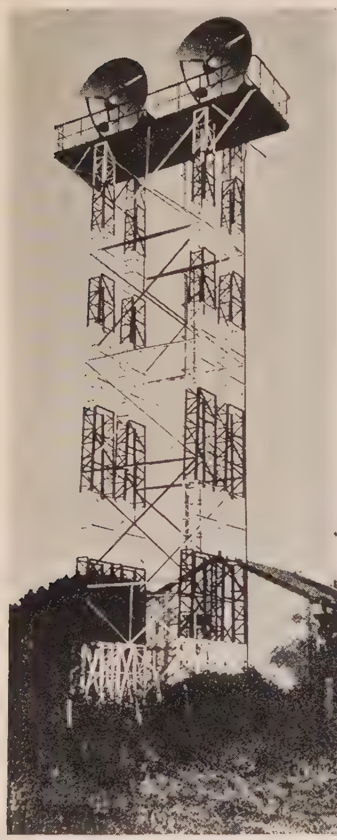
Chemistry and Agriculture

In the field of the chemical industries the story of the past 50 years is substantially similar to that of the electrical and automotive industries. Though far more ancient than either of these industries and with an origin lost in the mists of antiquity, the great advances in the chemical industries have come during the past 50 years and have been the direct result of organized scientific research applied to materials and to the processes by which materials are created. Not only have the materials and processes of inorganic chemistry been amplified enormously, but substantially the whole field of organic chemistry has been created. When we consider the very considerable number of the so-called elements and the incredible number of possible permutations and combinations of them, it seems likely that in the years ahead continuation and amplification of the scientific method in the field of chemistry is more likely than not to dwarf into insignificance the surprising results of our achievements during the past half-century.

Except as regards the application of mechanical devices for the purpose of saving labor, we do not commonly visualize very clearly the effect of scientific research during the past 50 years on that most ancient of man's undertakings, agriculture. In no single sector, however, have the results of scientific research been so extensive or so far reaching in their effect on human well being as in the broad field of agriculture. During the past 50 years, as a direct result of scientific research we have learned more about soil chemistry and soil mechanics than man ever knew before. By the same means we have learned how to produce new species and to adapt old species to new environments. Through organized, intensive research work in the various fields of the botanical and biological sciences we have learned how to control plant diseases and plant pests which would otherwise at times and in places completely destroy many forms of agriculture. The very advances that have resulted from research, particularly in the field of rapid transportation, have changed the whole complexion of the agricultural problem. Plant diseases and plant pests, which in an earlier age were definitely localized in their point of origin because they could not survive the long period involved in transportation to a distant point, became a devastating menace with the advent of rapid transportation. That much of agriculture, as we know it, has not fallen victim to this menace is wholly and solely the result of organized research

designed to ferret out the necessary controls, and of engineering based on this research that has made those controls effective.

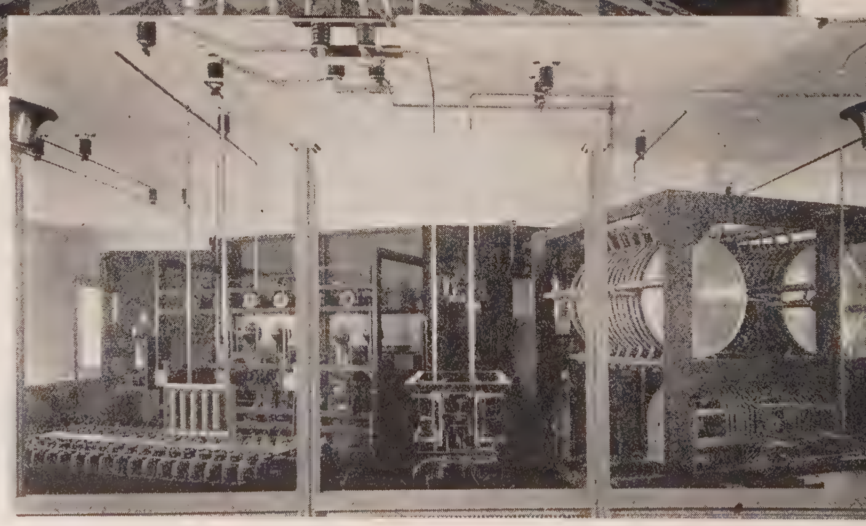
A category of examples similar to the foregoing could be extended almost without end. Except, however, as multiplicity of numbers gives weight to proof, such an extension would add nothing to the research picture presented by the progress of the past 50 years. In this field the semi-centennial milestone of the American Institute of Electrical Engineers, which we are this spring unveiling, marks not only a notable period in the life of a great insti tution concerned with a great group of industries but also the end of 5 very notable decades in the lif of all industries that are organized on bases of applie science. What pictures looking backward in 198 will show, only our children or their children can see From our present point of view there is no reason however, to believe that these pictures will disclos results growing out of industrial research any les striking than those we now see when we look back ward over 50 years of progress.



One of the transmitting towers of the Anglo-French micro-ray communication link between Lympe, England, and St. Inglevert, France, a distance of 35 miles. Operating on a wave length of 17.4 cm, this installation represents the shortest wavelength radio telephony in regular commercial exploitation today and may be considered as heralding an era in which the practical advantages of privacy, efficiency, and reliability of these extremely small wavelengths will be exploited to the full
(International Tel. & Tel. Co. photo)

(Right) Combined studio and transmitter of the original KDKA radio station which began broadcasting November 2, 1920
(Westinghouse photo)

(Below) Transmitting room of a modern radio broadcasting station, WEAF at Belmore, Long Island (RCA photo)

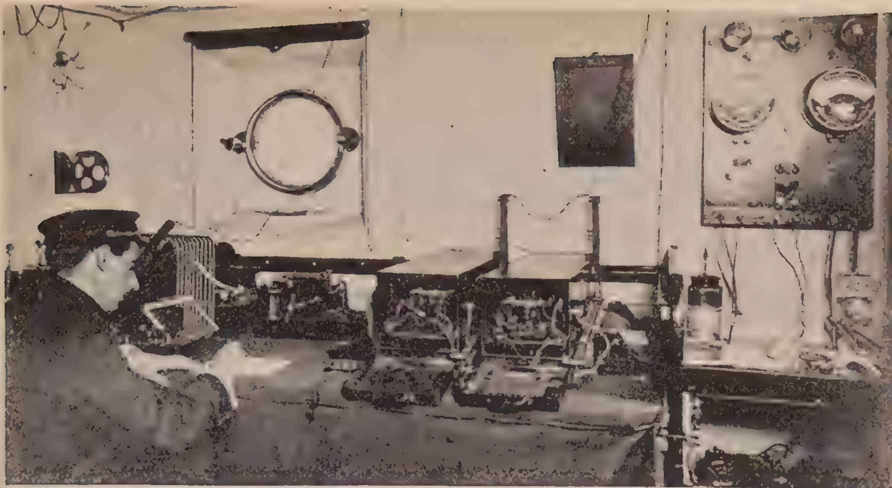


(Right) Back of power amplifier of radio station WEAF at Belmore, Long Island
(RCA photo)

Some Contrasts in

Radio Equipment

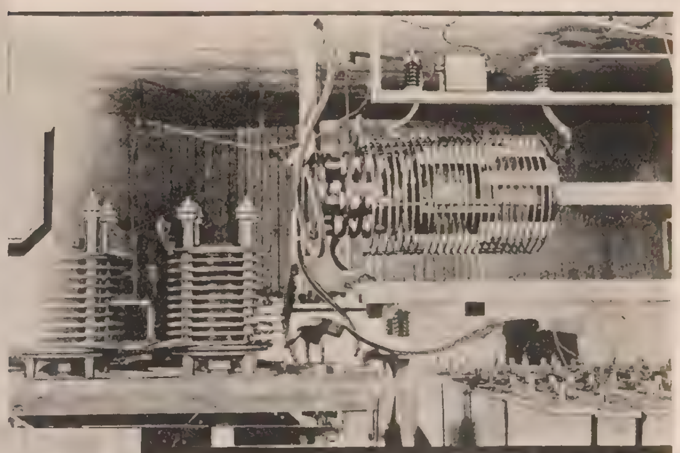
(This and Facing Page)



(Left) A 1901 marine radio telegraph set on the S.S. "Philadelphia"
(RCA photo)

A modern marine radio telegraph installation on the S. S. "Gulf Pride"; this consists of a 500-watt intermediate and long wave transmitter, and an intermediate wave receiver
(RCA photo)

(Below) Some contrasts in radio transmitting tubes (reproduced in proportionate sizes): 2 modern 100-kw tubes, each more than 4 ft long; transatlantic transmitting tubes of 1927 and 1915 (left below); and a tube used to modulate an Alexanderson alternator in radio-telephone tests between Pittsfield, Mass., and Schenectady, N. Y., in 1914 (bottom)
(Am. Tel. & Tel. and General Elec. photos)



(Above) Early radio telegraph apparatus used in transoceanic communication
(RCA photo)

(Left) A modern 20-kw short wave transmitter with crystal control used for present-day transoceanic telegraph service
(RCA photo)

Great Names Behind the Institute

THE TRUTH of the often-repeated statement that the history of any organization can be traced in the lives of its leaders, is borne out by the records of the American Institute of Electrical Engineers. The names of the leaders of the A.I.E.E. comprise an imposing list, one which any organization would be proud to claim.

The influence which those prominent in the Institute have had on society cannot be over-estimated, as it is so far-reaching, and extends in an intangible way through the lives and acts of many thousand individuals. Some conception of the magnitude of the influence which these men have had on their fellow-beings may be gained from the fact that a surprisingly large proportion of the Institute's leaders are not only well known within the electrical engineering profession, but are famous with men in all countries throughout the world.

On this and the following page are listed the names of those who have served as presidents from the founding of the Institute in 1884 until the present day, the names of those who have been elected to honorary membership in the Institute, the names of those who have been awarded any of the 3 medals in which the Institute is most deeply interested, the names of those faithful individuals who have served the Institute either as secretaries or treasurers, and the names of the 6 living charter members of the Institute. On the 37 pages which follow this listing, there are given biographical sketches of these leaders of the Institute, concluding with a list of the 71 pioneers in the electrical industry who, as nearly as can be determined from records at Institute headquarters, were charter members of the Institute.

Presidents of the Institute

FROM the Institute's first president, Dr. Norvin Green, down to and including the incumbent, Dr. J. B. Whitehead, 46 outstanding leaders have served the Institute as presidents. These, together with their term of service, are:

Norvin Green	1884–86
Franklin L. Pope	1886–87
T. C. Martin	1887–88
Edward Weston	1888–89
Elihu Thomson	1889–90
W. A. Anthony	1890–91
Alexander Graham Bell	1891–92
Frank J. Sprague	1892–93
Edwin J. Houston	1893–95
Louis Duncan	1895–97
F. B. Crocker	1897–98
A. E. Kennelly	1898–1900
Carl Hering	1900–01
C. P. Steinmetz	1901–02
Charles F. Scott	1902–03
Bion J. Arnold	1903–04
John W. Lieb	1904–05
S. S. Wheeler	1905–06
Samuel Sheldon	1906–07
Henry G. Stott	1907–08
L. A. Ferguson	1908–09
L. B. Stillwell	1909–10
D. C. Jackson	1910–11
Gano Dunn	1911–12
Ralph D. Mershon	1912–13
C. O. Mailloux	1913–14
Paul M. Lincoln	1914–15
John J. Carty	1915–16
H. W. Buck	1916–17
E. W. Rice, Jr.	1917–18
Comfort A. Adams	1918–19
Calvert Townley	1919–20
A. W. Berresford	1920–21
Wm. McClellan	1921–2
Frank B. Jewett	1922–2
Harris J. Ryan	1923–2
Farley Osgood	1924–2
M. I. Pupin	1925–2
C. C. Chesney	1926–2
Bancroft Gherardi	1927–2
R. F. Schuchardt	1928–2
Harold B. Smith	1929–3
W. S. Lee	1930–3
C. E. Skinner	1931–3
H. P. Charlesworth	1932–3
J. B. Whitehead	1933–3

Honorary Members of the Institute

THE INSTITUTE has elected 31 distinguishe citizens of various countries of the world to th highest grade of membership in the Institute, namely Honorary Member. Previous to the election o Thomas A. Edison to honorary membership in 1928 all Honorary Members with the exception of Prof Moses G. Farmer and Cyrus W. Field, had bee citizens of countries other than the United States Since 1928, the tendency has been more to hono those who have served the Institute directly.

As an aid to those who may wish to turn to th biographical sketch of some Honorary Member in th pages which follow, these sketches are given immedi ately after those of the presidents, and are given i the chronological order of election. In the case of those names in the following list which are followe by an asterisk, biographical sketches will not b found in the group of Honorary Members, but wi have been given in the group of presidents, as thes Honorary Members also served as presidents.

Sir William Preece	1884
Norvin Green*	1889
Moses G. Farmer	1890
Lord Kelvin	1892
Cyrus Field	1892
E. W. von Siemens	1892
Andre Blondel	1912
C. E. L. Brown	1912
Emil A. Budde	1912
S. Z. de Ferranti	1912
Antonio Pacinotti	1912
S. P. Thompson	1914
Guglielmo Marconi	1917
Oliver Heaviside	1918
Ferdinand Foch	1921
Thomson A. Edison	1928
John J. Carty*	192
M. I. Pupin*	192
Ambrose Swasey	192
Elihu Thomson*	192
Herbert Hoover	192
Charles F. Scott*	192
Charles F. Brush	192
Motoji Shibusawa	192
Frank J. Sprague*	193
W. L. R. Emmet	193
G. A. Hamilton	193
Arthur E. Kennelly*	193
R. A. Millikan	193
E. W. Rice, Jr.*	193
Edward Weston*	193

* Included in the group of Past-Presidents.

Edison Medalists

THE EDISON MEDAL Association was originally organized for the purpose of appropriately recounting and celebrating the achievements of a quarter of a century in the art of electric lighting. It was felt by the Association that the most effective means of accomplishing the object for which it was formed would be the establishment of a gold Medal, which should, during the centuries to come, serve as an honorable incentive to scientists, engineers, and artisans to maintain by their works a high standard of accomplishment. The Medal, highest award of the Institute, was established on February 11, 1904, and is awarded once each year to some one resident of the United States of America and its dependencies, or of the Dominion of Canada, for "meritorious achievement" in electrical science or electrical engineering or the electrical arts.

In the cases of those names in the following list which are followed by an asterisk, biographical sketches will not be found in the group of Edison Medalists, but will have been given in the group of presidents or honorary members.

Elihu Thomson*..........1909	R. A. Millikan*..........1922
Frank J. Sprague*.........1910	John W. Lieb*...........1923
George Westinghouse......1911	John W. Howell..........1924
William Stanley..........1912	Harris J. Ryan*..........1925
Charles F. Brush*.........1913	W. D. Coolidge..........1927
Alexander Graham Bell*...1914	Frank B. Jewett*.........1928
Nikola Tesla.............1916	Charles F. Scott*.........1929
John J. Carty*...........1917	Frank Conrad...........1930
Benjamin G. Lamme......1918	E. W. Rice, Jr.*..........1931
W. L. R. Emmet*.........1919	Bancroft Gherardi*........1932
M. I. Pupin*.............1920	Arthur E. Kennelly*.......1933
C. C. Chesney*...........1921	

John Fritz Medalists

THE JOHN FRITZ Medal is awarded annually by a board composed of 4 representatives of each of the 4 national engineering societies, the American Institute of Electrical Engineers, The American Society of Mechanical Engineers, the American Institute of Mining and Metallurgical Engineers, and the American Society of Civil Engineers, for notable scientific or industrial achievements, regardless of nationality or sex. It was established by professional associates and friends of John Fritz on August 21, 1902, his eightieth birthday, to perpetuate the memory of his achievements in industrial progress. The first award of the medal was to John Fritz at a dinner given on his eightieth birthday.

Those members of the Institute who have been awarded the John Fritz Medal follow. In this list, an asterisk following the name indicates that the biographical sketch is given in one of the preceding groups.

Lord Kelvin*.............1905	Ambrose Swasey*.........1924
George Westinghouse*.....1906	Edward D. Adams........1926
Alexander Graham Bell*...1907	Elmer A. Sperry..........1927
Thomas A. Edison*........1908	John J. Carty*...........1928
Elihu Thomson*..........1916	Herbert Hoover*.........1929
Guglielmo Marconi*.......1923	M. I. Pupin*............1932

Lamme Medalists

A BEQUEST was made by the late Benjamin G. Lamme, chief engineer of the Westinghouse Electric and Manufacturing Company, to provide for the award by the Institute of a gold medal annually to a member of the A.I.E.E., "who has shown meritorious achievement in the development of electrical apparatus or machinery."

The award is made in accordance with conditions specified in the by-laws of the Lamme Medal committee.

In the list of Lamme Medalists which follows, an asterisk following the name indicates that the biographical sketch of the medalist is given in one of the preceding groups.

Allan B. Field............1928	Giuseppe Faccioli.........1931
R. E. Hellmund...........1929	Edward Weston*..........1932
William J. Foster..........1930	Lewis B. Stillwell*........1933

Secretaries of the Institute

THE secretaries of the Institute have in general held office for long terms. Although subject to reëlection or reappointment each year, the terms of service of the 4 secretaries, as indicated below, cover the entire 50-year span of the Institute's history.

N. S. Keith..........1884–85	F. L. Hutchinson.......1911–32
Ralph W. Pope......1885–1911	H. H. Henline.........1932–

Treasurers of the Institute

THE treasurers of the Institute have also included long terms of service. With the unusual record of continuous service from 1895 to 1930 for Mr. Hamilton (see p. 816, 821, and 823), the terms of 4 treasurers span the 50 years, 1884–1934. The 4 treasurers are:

Rowland R. Hazard....1884–86	G. A. Hamilton*.....1895–1930
George M. Phelps......1887–95	W. I. Slichter........1930–

Charter Members of the Institute

OF THE 71 individuals who have been definitely determined to have been charter members of the Institute, 6 are now living and still on the rolls. These living charter members, who will be presented with certificates and membership badges through the Sections of which they are members, are:

Charles L. Clarke	Frank B. Rae
E. N. Dickerson	Elihu Thomson*
George A. Hamilton*	Edward Weston*

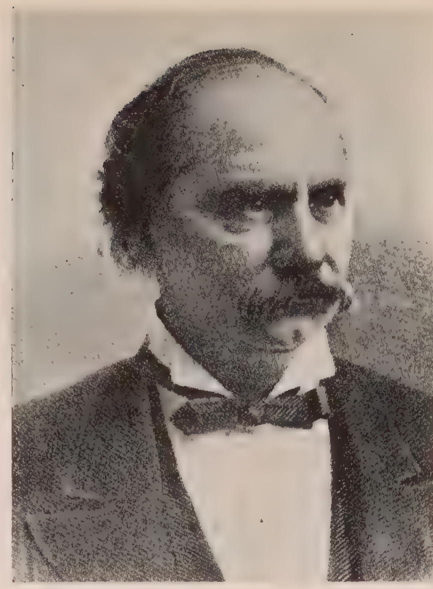
* Included in a previous group.

Norvin Green

(Associate 1884, Member 1884)

President 1884–85–86

Honorary Member 1889



THE INSTITUTE'S first president was a physician, who, having become interested in politics, was placed in a government position which led to his becoming one of the lessees of an early telegraph company, and subsequently president of the Western Union Telegraph Company. This physician was Dr. Norvin Green, a charter member and one of the founders of the Institute.

He was born April 17, 1880, at New Albany, Ind. His early life was spent in Kentucky; here he graduated with high honors at the University of Louisville in 1840. Shortly afterward he became a physician for the Western Military Academy, Drennon Springs, Ky., of which James G. Blaine, who later became a prominent statesman and was twice U.S. Secretary of State, was one of the junior instructors.

Doctor Green also became interested in politics. He was elected for a number of years as a member of the Kentucky Legislature and in 1853 was appointed a Commissioner of the United States in charge of the construction of national buildings in Louisville. While engaged in these duties he became one of the lessees of the United Morse and People's Telegraph Lines, between Louisville and New Orleans, later becoming president of these interests, united under the name of the Southwestern Telegraph Company.

In 1866, when the America, the United States, and the Western Union companies were consolidated, Doctor Green was chosen vice-president of the Western Union Company, and, which office he held up to 1878, with the exception of the 3 years from 1870 to 1873; during this period he was the president of the Louisville, Cincinnati and Lexington Railroad Company, and again entered politics, barely losing the nomination for U.S. Senator from Kentucky.

In 1878, Doctor Green was elected president of the Western Union Telegraph Company, holding this position until his death, February 12, 1893, at the age of 75 years.

It was from this background that Doctor Green entered heartily into the organization of the Institute. He was an ardent worker for its establishment and set the example of conscientious attention to duty He was sanguine in his prediction of the Institute's future usefulness, and in spite of his many business ca es he was at almost all of the council meetings, acting as presiding officer. He had considerable committee work put upon him and was instrumental in laying out the work of the Institute during those first 2 years. It was said of him in those early days that no person connected with the Institute exhibited more interest and did more for its future advancement than did Doctor Green. At the end of his first term of presidency, Doctor Green unanimously was elected to serve as President for another year, 1885–86.

At the end of this period he was elected to serve 2 years as vice-president c ntinuing to give advice and assistance thereafter.

Franklin L. Pope

(Associate 1884, Member 1884)

President 1886–87

SUCCEEDING Dr. Norvin Green, the second president of the Institute was Franklin Leonard Pope, one of the earliest practicing electrical engineers in the country. Mr. Pope, like many of the charter members of the Institute, was act ve principally in the telegraph and telephone field.

He was born at Great Barrington, Mass., December 2, 1840. After attending the academy in Amherst, Mass., he became a telegraph operator in 1857. In 1859 he entered the drafting department of the *Scientific American* in New York City, but in 1861 reëntered the telegraph service in Providence, R. I. In 1862, he was made assistant engineer of the American Telegraph Company in New York. During the draft riots the following year, he repaired with his own hands the demolished telegraph lines of this company between New York and Boston. When the national telegraphic union was formed in 1863, Mr. Pope was chosen the New York District Secretary; under the pseudonym of "Elektron," he was the first contributor to its publication, *The Telegrapher*.

In 1864, Mr. Pope was appointed assistant engineer and chief of the geographical department of the Western Union Russian Extension Company, and surveyed the route for the proposed Collins Overland Telegraph between British Columbia and Alaska, which was abandoned after the successful laying of the Atlantic cable. Returning to New York in 1866, Mr. Pope resumed the contribution of articles to *The Telegrapher*, and its editor 1867–68.

In 1868, he undertook the development and management of a system of printing the prices of gold and of stock in brokers' offices. In 1869, he entered into partnership with Thomas A. Edison under the name of Pope, Edison & Company, electrical engineers, and in 1870 they invented a one-wire printing telegraph. This firm had but a brief existence, being dissolved in 1870, probably because of the strong personalities of its members. Continuing in active practice, Mr. Pope secured several patents, the majority of them being for a railroad semaphore lock signal system. He was one of the earliest patent solicitors for electrical inventions, and was for many years patent attorney for the Western Union Telegraph Company.

Mr. Pope was the author of "Modern Practice of the Elect ical Telegraph" (1871, rewritten 1891), and "Life and Work of Joseph Henry" (1879). In 1884 he became editor of the *Electrical Engineer*, which was later called *The Electrician and Electrical Engineer*, and still later *The Electrical Engineer*. He also edited the electrical department of *The Engineering Magazine*.

In 1894, Mr. Pope returned to Great Barrington, having reconstructed an old brick house built there in 1766. As a pastime, he remodeled the Great Barrington Electric Light Company's system, describing these changes in an Institute paper. Mr. Pope had the primary wires brought into his cellar, and because of an accidental contact with these wires he was killed on October 13, 1895. Mr. Pope had been a member of the Institution of Electrical Engineers (British) since its inception in 1872 and had been one of its first vice-presidents. In 1878 he was vice-president of the American Electrical Society of Chicago. He was an older brother of Ralph W. Pope who, for 27 years, starting in the year 1885, served the Institute as secretary.

T. Commerford Martin

(Associate 1884, Member 1910)

President 1887–88

FOR its third president the Institute chose an editor of electrical magazines, author, and association executive. He was Thomas Commerford Martin, who assumed the presidency of the Institute at the age of 30.

Mr. Martin was born in London, England, July 22, 1856. Owing to the relation of his father to the pioneer submarine cable industry, the boy had the unique experience of spending much of his time on the historic cable-laying steamship "Great Eastern" and of making the early acquaintance of Professor William Thomson (Lord Kelvin). Although educated as a theological student, Mr. Martin came to the United States in 1877; entering the service of Thomas A. Edison that year, he had much to do with several famous inventions, and wrote many articles in the New York papers on them, notably on the telephone, microphone, and phonograph. Due to ill health, he resigned in 1879 and went to the West Indies, where he undertook journalistic adventures and work for the Government of Jamaica. Returning to New York in 1882, he edited *The Operator*, and in 1883, as one of the editors of the *Electrical World*, got out its first issue practically single handed. He remained as its editor for 26 years.

Then, in 1909, he was elected secretary of the former National Electric Light Association, which he had helped to found in 1885. On account of impaired health, he resigned in 1919, becoming advisory secretary. His annual report on the progress of the industry was for many years a leading feature of N.E.L.A. conventions. In 1923 he also became secretary of the New York Electrical Society, of which he had been a charter member, and in 1900, its president. He died May 17, 1924.

Mr. Martin was not only very active in 1884 as a founder and charter member of the A.I.E.E. and as its acting secretary at that time, but he had served in all of its elective offices except that of treasurer. Mr. Martin was also in trumental in the purchase by Doctor Schuyler Skaats Wheeler of the Lattimer Clark Library for the Institute, and the securing of the famous gift of $1,500,000 from Andrew Carnegie for the Engineering Societies Building and Engineers' Club. He served for 4 years on the 2 building committees, and as president opened the new building with Doctor Carnegie in 1907. He was president of the Engineers' Club of New York 1907–08.

Mr. Martin was the author of numerous electrical books, and contributed frequently to the leading American encyclopedias and magazines. As special electrical expert for the U.S. Census Office between 1900 and 1915, his reports on the vast range of electrical industries and utilities were of tremendous importance. He lectured widely in this and other countries. He was decorated by the French Government as Officer de l' Instruction Publique in 1907. He was one of the founders of the American Museum of Safety and of the Illuminating Engineering Society. He had represented the Institute and 3 other American societies at the Kelvin Jubilee in 1896 at Glasgow University. He was a member of several other engineering and scientific societies

Edward Weston

(A '84, M '84, member for life)

President 1888–89
Honorary Member 1933
Lamme Medalist 1932

EDWARD WESTON, now chairman of the board of the Weston Electrical Instrument Corporation at Newark, N. J., and one of the 6 living charter members of the Institute, was elected as the fourth president of the A.I.E.E. The citation accompanying the award to him of the Institute's Lamme Medal in 1932 "for his achievements in the development of electrical apparatus, especially in connection with precision measuring instruments," aptly phrases the outstanding interest of his long and active life.

Doctor Weston was born in Shropshire, England, in 1850, and received his formal education in that country. From boyhood he manifested a keen interest in electrical and mechanical investigations. Coming to New York City in 1870, he spent 2 years as chemist and electrician for industrial concerns, then established his own nickel plating business in 1872, maintaining this activity until 1875, when he became a partner in a firm for the manufacture of dynamo-electric machines.

The business of this firm was incorporated as the Weston Company in 1877, and in 1881 was consolidated with the U.S. Electric Light Company, of which Doctor Weston served as electrician until 1888. While in this position he received many patents on dynamo construction, and conducted extensive investigation in the lighting field

At this time he encountered in all his researches great difficulty in making the necessary electrical measurements with the clumsy, slow acting instruments then available; he therefore developed and built for his own experiments a set of more practical instruments. These were so successful that in 1888 he decided to relinquish his other interests and devote all his time to the research and development necessary to produce accurate and convenient electrical instruments. He established the Weston Electrical Instrument Company, of which he served as vice-president and general manager from 1888 until 1905, and president from 1905 to 1924, when he became chairman of the board. His achievements in developing instruments of a high speed of accuracy and portability are well known. In 1908, the Weston standard cell was accepted as the universal standard of electromotive force.

In addition to being a charter member of the Institute, Doctor Weston was a member of its first board of directors and served as manager 1884–87. Following his term as president, he was vice president 1889–91. He is a member of several other engineering and scientific societies, being an honorary member of the Franklin Institute. Doctor Weston has received the honorary degrees of doctor of laws from McGill University,

1903; doctor of science, Stevens Institute of Technology, 1904, and Princeton University, 1910. His interest in the younger members of the profession is known by his establishment of a fellowship in electrochemistry, managed by the Electrochemical Society. This fellowship of $1,000 is awarded each year to a candidate under 30 years of age who shows marked capacity in carrying out research in electrochemistry or its applications.

Elihu Thomson

(A '84, M '91, F '13, member for life)

President 1889–90
Honorary Member 1928
Edison Medalist 1909
John Fritz Medalist 1916

ELIHU THOMSON, fifth president of the Institute and one of the 6 living charter members, has a record in electrical engineering that can hardly be paralleled by any other individual living at present. Throughout almost the entire period of the development of electrical theory and apparatus, Professor Thomson has been deeply interested in all phases of electrical engineering. He has freely passed on to others the tremendous store of information that he has collected. As one small note of appreciation of his generous efforts, his friends continue to call him by the title of professor, even though more dignified titles may be applied.

He was born in Manchester, England, March 29, 1853, being brought to the United States in 1858, settling in Philadelphia. Upon graduating from Central High School, Philadelphia, in 1870, he was at once appointed assistant professor of chemistry of that institution. He was full professor from 1876 to 1880, when he resigned to devote his entire time to electrical research.

His unusual inventive genius and his marked ability to learn quickly, were apparent even during his early years. Professor Thomson's first important invention was the 3-coil arc dynamo which, with its automatic regulator and other novel features, was the basis of the successful electric lighting system produced by the Thomson-Houston Electric Company, beginning in 1880. This company was established in Philadelphia in 1879 by Professor Thomson and E. J. Houston, his former colleague at the high school who later, 1893–95, also was a president of the Institute. The company moved to New Britain, Conn., in 1880 and then to Massachusetts in 1883, merging in 1892 with the Edison General Electric Company to become the General Electric Company. In the early years of the new company Professor Thomson was elected chief engineer, many of fundamental inventions upon which the present industry is based being his. Professor Thomson is today consulting engineer of the General Electric Company and director of its Thomson Research Laboratory at Lynn. During his career some 700 patents have been taken out by Professor Thomson, these covering almost every field of electrical activity.

Professor Thomson was the recipient of the Institute's first Edison Medal, and has received some 15 medals in this and other countries, as well as other honors. These include 3 notable medals of Great Britain; in 1916 he was the recipient of the Hughes Medal bestowed by the Royal Society; in 1924 he was honored by the award of the Kelvin Medal, given by all the technical and engineering bodies of England with the concurrence of the leading engineering societies of America; and in 1927 he was presented by the Institution of Electrical Engineers, of England, with the Faraday Medal.

In 1889 he was decorated by the French Government for his electrical inventions, being made a chevalier and officer of the Legion of Honor.

He was awarded the Rumford Medal, in 1901; the Grand Prix at the Paris Expositions of 1899 and 1900; the John Fritz Medal of 1916; and the Elliott Cresson Gold Medal from the Franklin Institute. He has twice received the John Scott Medal for electrical inventions. Honorary degrees have been conferred upon him by several institutions.

In addition to serving the Institute as vice-president 1887–89, and then as president, he has been active on the committee of coöperative research 1898–1900, the committee on standardization 1898–1900, and the Edison Medal committee, of which he was chairman 1911–15. He served as the Institute's representative on the U. S. National Committee of the International Electrotechnical Commission for many years preceding 1930.

William A. Anthony

(Associate 1884, Member 1885)

President 1890–91

THE first 5 presidents of the Institute had all been charter members. The sixth president, William Arnold Anthony, was elected an associate December 9, 1884, while a professor of Physics at Cornell University. Although a few months late in getting started, he immediately took an active part in Institute affairs and was elected a vice-president in 1886, serving for 3 years.

He was born at Coventry, R. I., November 17, 1835. He entered Sheffield Scientific School at Yale University and graduated at the head of his class, with the degree of Ph.B., in 1856. For a short time following his graduation he was principal of the public schools at Crompton, R. I., and taught for a year in the Providence Conference Seminary. Following a year in a cotton machinery manufacturing plant, to acquire a knowledge of tools, he resumed teaching, first at the Delaware Literary Institute, Franklin, N. Y., and later at Antioch College, Ohio.

He was professor of mechanics and physics at Iowa State Agricultural College at Ames, from 1869 to 1872 thence going to Cornell University where he remained as professor of physics until 1887. During the 15 years there he did much to originate and develop the course of study in electrical engineering. From 1887 until 1893, he was consulting engineer at the Mather Electric Company, Manchester, Conn. In the latter year he opened an office in New York City as consulting electrical engineer, and in 1894 became connected with the Cooper Union night school of science as professor of physics. In February 1908 he was retired as professor emeritus, and died May 29 of that year.

He was one of the authors of Anthony and Brackett's "Manual of Physics" (1887) and in 1898 he published "Lecture Notes on the Theory of Electrical Measurements." Although of a quiet and unassuming disposition, Prof. Anthony nevertheless received full recognition for his work from an appreciative class of co-workers in the electrical field.

He served the Institute on the membership and the coöperative research committees, and was the first local secretary for the Manchester, Conn., section, 1888. He was a member of the Franklin Institute of Philadelphia, the American Social Science Association, and the Brooklyn Institute of Arts and Sciences.

Alexander Graham Bell

(Associate 1884, Member 1884)

President 1891–92

Edison Medalist 1914
John Fritz Medalist 1907

ALTHOUGH he did much other important scientific work in various fields Alexander Graham Bell has been known the world over as the inventor of the telephone, and thus may be said to have made one of the most revolutionizing contributions to modern civilization to date.

Doctor Bell was born in Edinburgh, Scotland, in 1847, the son and grandson of teachers of vocal physiology and the laws of speech, and this, in addition to the fact that 2 members of his immediate family were deaf, undoubtedly was responsible for his interest in all matters pertaining to the human voice. At 14, he was sent to London for instruction in elocution and phonetics by his grandfather. Later he returned to Edinburgh to study at the University, and in a short time he was assistant to his father who had obtained a post as lecturer in elocution at University College, London. There he met Wheatstone and Ellis and became interested in Helmholtz's work on the electromagnetic control of tuning forks.

When he was 23, the Bell family emigrated to Canada, and the next year Doctor Bell was appointed instructor at the first school for the deaf and dumb in Boston. He was a very successful teacher and later taught at both Boston and Oxford universities. In inventing the telephone he was first seeking some way, perhaps by registering graphically on paper, to show his pupils the variations in tones and the inflections of the human voice. Into the poorly equipped electric shop of Charles Williams, typical of that period when a "laboratory" was unheard of, Doctor Bell took his first problems and ideas of the "harmonic telegraph," "harp telephone," and speaking telephone.

By 1875, after continuous experimentation, he was at work upon the specifications of the patent for the telephone, and in 1876 it was granted. The Centennial Exhibit at Philadelphia in 1875 did much to convince business men that the instrument was practical, and soon thereafter a 2-mile line was installed between Boston and Cambridge over which ordinary reciprocal conversation was carried on. By 1887 long-distance conversations between New York and Boston were possible.

Doctor Bell was an active researcher until the time of his death in 1922. Besides the telephone he invented the photophone, a device which transmitted speech by light beams, induction balance and telephone probe, and helped to develop the graphophone. He constructed a number of tetrahedral aeroplanes and experimented with propellers.

He was a charter member of the Institute, a member of many American and foreign societies and the recipient of honors from governments and learned institutions, including the decoration of the Legion of Honor from France, Volta Prize (1880), Albert Medal of the Society of Arts (London, 1902), Hughes Medal of the Royal Society of England, and Elliott Cresson Medal of the Franklin Institute.

Frank J. Sprague

(A '87, M '97, F '12, member for life)

President 1892–93
Honorary Member 1932
Edison Medalist 1910

OF THE early developers of electric motors and electric traction, Frank Julian Sprague is preëminent. His unflagging spirit and courage both as an inventor and as a financial manager had much to do with the successful development and operation of the electric trolley, the constant speed motor, the multiple unit, regenerative and remote control systems, and considerable equipment for elevator operation.

Mr. Sprague was born in Milford, Conn., in 1857. He early demonstrated his ability as a "financier" by borrowing money to attend the United States Naval Academy. It was while attending the Academy that the telephone was invented and his interest was aroused in things mechanical and electrical. He carried on experimentations in his free time, and in 1885, he resigned from the Navy and began his career as an electrical engineer, assisting Edison for one year. During this time he devised a mathematical system for determining the characteristics of central station distribution of electricity. Then he established his own enterprise, the Sprague Electric Railway and Motor Company, and immediately began the application of electric motors to all kinds of stationery work, equipping the first electrically trained gun on the S. S. "Chicago." In 1887 he undertook a contract with the City of Richmond, Va., to plan, finance, and put into operation a street railway, the first successful system to be operated. Within 2 years his firm had received more than 100 contracts for similar work all over the country and in Italy and Germany as well.

In the course of his career, he has organized a number of concerns bearing his name, some of which merged with such organizations as the General Electric Company. He is now president of the Sprague Safety Control and Signal Corporation and the Sprague Development Corporation.

Among his achievements are the introduction of electric high speed and house elevators, development of the automatic signaling and brake train control systems, and invention of the method of operating 2 elevators on the same rails in a common shaft. He has taken a keen interest in electrical traction in general, advocating underground rapid transit through the whole period of its development in New York City; also he has been interested in the electrification of the railroad, having served on the Grand Central Terminal Electrification Commission.

Mr. Sprague has long been active in Institute affairs, serving at various times as committeeman and as vice-president (1890–92). He represented the Institute and Inventors Guild on the U.S. Naval Consulting Board and was engaged in developing fuses and air and depth bombs during the war. He is a member of many technical societies; past-president of the New York Electrical Society, American Institute of Consulting Engineers, and the Inventors Guild; and the recipient of many distinctive awards.

Edwin J. Houston

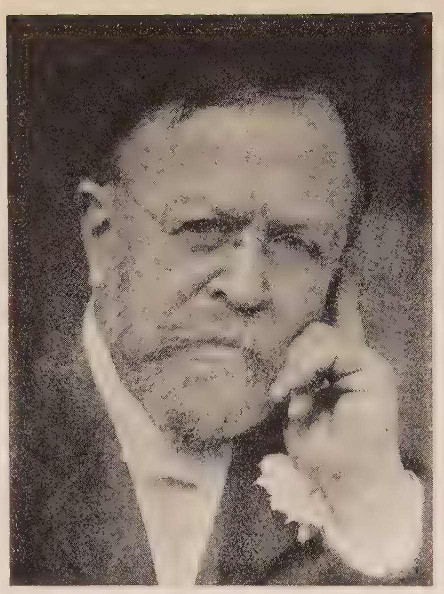
(A '84, M '84, Life Member)

President 1893–94–95

IN THE days when electric lighting was a new subject Edwin James Houston attained fame by working out the Thomson-Houston system of arc lighting. In collaboration with Professor Elihu Thomson who was a teacher at the same school, Professor Houston made many important contributions to the art, establishing a high reputation as an inventor in addition to his eminence as a teacher, author, and consulting engineer.

He was born in Alexandria, Va., July 9, 1847 and was educated in the Central High School of Philadelphia, from which he received the Master's degree. After teaching for a time at Girard College, he was elected professor of civil engineering in the Central High School, but was soon transferred to the chair of natural philosophy, of which he was professor emeritus at the time of his death, March 1, 1914. He was also professor emeritus of physics at Franklin Institute and professor of physics at the Medico-Chirurgical College.

In 1884 he was appointed a member of the United States Electrical Commission, which convened at Philadelphia, and was elected by the Franklin Institute chief engineer of the International Electrical Exhibition in



Philadelphia. This exhibition was well carried out, and the practical tests of electrical apparatus then made were a valuable contribution to the advance of electrical science. By this time Professor Houston had become prominent in electrical research of every sort, and the following year, in 1895, he resigned from his position at the Central High School to become associated with Dr. A. E. Kennelly in the firm, Houston and Kennelly, consulting engineers.

Professor Houston was a very prolific writer both in the technical and popularized fields of science. He was keenly alive to the growing importance of science in education and wrote many textbooks and "popular" essays, as well as numerous purely scientific papers.

The series "Primers of Electricity," published in 1884 in the *Electrical World*, which he wrote in collaboration with Dr. Kennelly, was among the first primers on electrical subjects appearing in any language. His "Dictionary of Electrical Words, Terms, and Phrases" and "Electricity in Every-day Life" are well known today. It was Professor Houston who presented the first paper before the Institute in 1884, "Some Notes on Incandescent Lamps," which dealt with the "Edison effect" and aroused a great deal of comment. The modern electronic tube is based upon this discovery.

He was a charter member of the Institute, a member of the American Institute of Mining Engineers, the American Philosophical Society, the Philadelphia Academy, and many other scientific organizations. He was president of Section C of the Electrical Congress held in Chicago in 1893 and the first president of the electrical section of the Franklin Institute. He received the honorary Ph.D. degree from Princeton University.

Louis Duncan

(A '87, M '87, F '13)

President 1895–96–97

ALTHOUGH prominent in the educational field, Louis Duncan was best known as an electrical traction expert and consulting engineer.

Doctor Duncan was born in Washington, D. C., March 25, 1861, and graduated from the United States Naval Academy in 1880. For about 6 years of service after graduation he was assigned part of the time to special duty at the Johns Hopkins University, to assist in determining the absolute unit of electrical resistance. For this work he received the Ph.D. degree from the university in 1885. In 1886 he resigned from the Navy and joined the teaching staff of Johns Hopkins, where he was in charge of a course in electrical engineering for 14 years. He inspired much original work on the part of his students.

At the same time he was occupied with various electrical engineering problems and was engineer in charge of construction of a number of electric roads in Baltimore, consulting engineer for many of the electric roads in Washington, chief engineer and in charge of construction of the Third Avenue System in New York, engineer for the Baltimore and Ohio Company, equipping the Baltimore tunnel with electric locomotives, and was consultant for a number of other railroad and lighting concerns.

In 1899, he resigned his position at the University and devoted his entire time to his consulting practice, organizing the firm of Sprague, Duncan and Hutchinson, but in 1902 when the Massachusetts Institute of Technology built a new electrical laboratory and separated the course of electrical engineering from the physics department, he was called upon to inaugurate the course, and the idea had such an appeal to him that he accepted and donned the professorial robes again for 2 years, as head of the electrical engineering department. He then returned to his practice and was active as a consulting engineer until his death February 13, 1916.

He took out several patents on devices for electrical machines, as well as patents on secondary batteries.

He did important consulting work for numerous utilities, including the Cincinnati Traction Company, the Indianapolis Traction Company, and many of the railroad companies in the Middle West. He was consulting engineer for the Rapid Transit Commission of New York City, chief engineer of the Keystone Telephone Company of Philadelphia, and of the independent telephone systems at Baltimore and Pittsburgh.

Doctor Duncan was the author of many articles on electrical subjects, and wrote on electricity for the Encyclopaedia Britannica. He was chairman of the board of judges at the Philadelphia Electrical Exhibition in 1885, a member of the board at the Atlantic Exposition and the World's Columbian Exposition at Chicago in 1892, and chairman of the electrical railroad section of the St. Louis Exposition in 1904. Doctor Duncan served as Major in the first volunteer engineers' corps during the Spanish-American War.

He contributed to the upbuilding of the Institute, serving 2 successive terms as president from 1895 to 1897, and also on several committees. He was an honorary member of the Franklin Institute, a member of the Mathematical Society of France, the Physical Society of France, the American Electrochemical Society, the American Philosophical Society, and others. He was associated with many other American and European scientific and technical organizations.

Francis B. Crocker

(A '87, M '99, Life Member)

President 1897–98

FRANCIS Bacon Crocker made his mark in the electrical engineering field as a pioneer designer of commercially successful motors, a distinguished educator, and a very able electrical engineer.

He was born in New York in 1861. From his childhood days he was interested in electricity, then barely known as a science, and as a boy he built successful telegraph and telephone lines. He attended school in New York and was graduated from the School of Mines of Columbia University in 1882, receiving the Ph.D. degree in electrical engineering in 1895. In 1899, he founded the department of electrical engineering and remained head of it for 20 years.

In 1883, Doctor Crocker with Charles G. Curtis organized the firm of Curtis & Crocker, one of the earliest electric motor manufacturing concerns. For 5 years they were engaged in patent and expert work, almost entirely electrical. Among their achievements was the invention and development of the "C. & C." electric motor. Upon the withdrawal of Mr. Curtis, owing to ill health, Doctor Crocker formed in 1888, with Schuyler S. Wheeler, the firm of Crocker & Wheeler, electrical engineers. This was the forerunner of the Crocker-

Wheeler Co., one of the most prominent establishments of its kind in the country. Doctor Crocker was a director of the company until the time of his death in 1921.

In addition to his academic and commercial interests Doctor Crocker gave much of his time and energy to the profession in his untiring efforts as an advocate of national and international standardization of electrical equipment. From the very beginning, he took a great interest in standardization, and if he had done nothing else, the excellence of this pioneer work in standardization, the ground work of which has remained virtually unchanged although the industry has undergone a most remarkable period of advancement, would be sufficient to single out Doctor Crocker as a notable in the electrical engineering world. In 1890 he became chairman of the first standardization committee of the Institute, serving several terms. In 1906 he was one of the 2 American delegates to the International Electrotechnical Commission which met in London. In 1913 he was appointed President of the United States National Committee of the Commission, and vice-president in 1916.

During the war Doctor Crocker was advisor for the members of the Naval Consulting Board, refusing to become a member, however, on account of poor health. His researches in aeronautics were of great importance, and many of his discoveries are now in practical application. In 1917 with Peter Cooper Hewitt he developed the first helicopter in this country which was able to fly. Successful inventors frequently sought his advice and information, and while he did not take out many patents in his own name, he was considered one of the best posted men on patents and he was able to aid greatly in the development of many uncompleted devices which others brought to him.

Arthur E. Kennelly

(A '88, M '99, F '13, Life Member)

President 1898–99–1900
Honorary Member 1933
Edison Medalist 1933

AMONG the notables in the scientific and scholastic as well as the practical provinces of electrical engineering is Arthur Edwin Kennelly.

Doctor Kennelly was born in 1861 in East India and was naturalized in 1906. He was educated at various private schools, scattered over Europe, including University College in London. He was awarded the honorary degrees of Sc.D., 1895, by the University of Pittsburgh, A.M., 1906, Harvard, and Sc.D., 1922, Toulouse, France.

His engineering career began at the early age of 14 when he acted as assistant secretary of the Society of Telegraph Engineers (now Institution of Electrical Engineers), in London. He had learned 3 signal systems and was employed as an operator by the Eastern Telegraph Company, by the time he was 15. He passed successively through the positions of assistant electrician, chief electrician of a cable repairing steamer and senior ship electrician on submarine cables. The familiarity gained in this submarine work with the theory and practice of transmission of signals over long lines with distributed capacity, because of the severe demands on his technical knowledge and resourcefulness, undoubtedly formed the basis for his future work in the field of telephony and in the mathematical treatment of the phenomena of transmission lines.

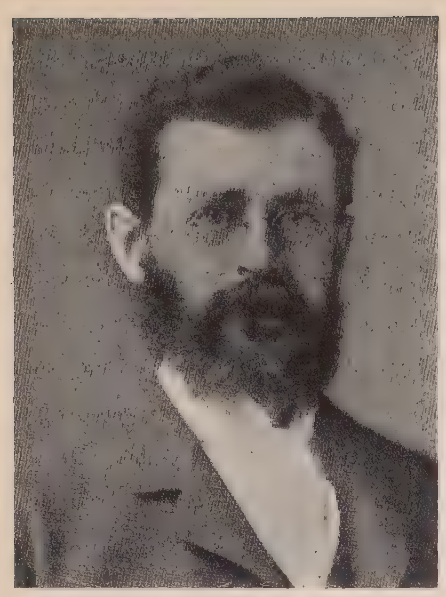
In 1887, when he was 26, he came to America and became the principal assistant to Edison, and later, in addition, was consulting electrician for the Edison General Electric and the General Electric

Companies; also, from 1894 to 1901 he was a member of the consulting firm of Houston and Kennelly. In 1902 he had charge of the laying of the Vera Cruz–Frontera–Compeche cable for the Mexican Government.

That same year Doctor Kennelly was appointed professor of electrical engineering at Harvard University, becoming professor emeritus in 1930 of that institution and of Massachusetts Institute of Technology, which positions he now holds. He was also professor of electrical communication, 1913–24, and chairman of the faculty, 1916–18, of the Massachusetts Institute of Technology. Several other educational distinctions have come to him.

He has been a prolific writer, enriching the literature by the publication of more than 300 papers and books. Perhaps the best known of his contributions to scientific knowledge is his explanation of the mechanism of the transmission of radio waves, published in 1902.

Doctor Kennelly has never swerved from his enthusiastic advocacy of standardization of electrical terms from the time when he became chairman of the committee on units and standards in 1890 to the present as chairman of the committee on electrical definitions of the Institute and as president of the International Electrotechnical Commission. He has served the Institute in many capacities and has been an officer and member of numerous other technical societies in this country and abroad, receiving many honors and awards.



Carl Hering

(A'88, M'88, F'12, Life Member)

President 1900–01

ONE of the outstanding figures in the electrical engineering world was Carl Hering, a pioneer in the field of design and construction of electrical apparatus. He was a productive researcher in electrochemical and electrophysical fields, and the discoverer of several fundamental natural laws.

He was born in Philadelphia, March 29, 1860, and was graduated in 1880 with the B.S. degree from the University of Pennsylvania, teaching there the next year as instructor in mathematics and assistant in mechanical engineering. In 1887 he received the M.E. degree and in 1912 the university conferred upon him the honorary degree of Sc.D. In 1882, becoming interested in electrical engineering, recognized then as a new and important branch of the art, Doctor Hering obtained a transfer to the department of physics. The following year he went to Germany to take courses at Darmstadt, teaching in the Polytechnikum there and working in Frankfort as chief engineer for Henry Moehring and Company, which manufactured and installed motors and dynamos. Upon his return to Philadelphia in 1886, he established a consulting practice which he continued until his death, May 10, 1926, specializing in work on electric furnaces, underground electrolysis and electrochemical and electrophysical processes.

He started the first comparative life tests of incandescent lamps in 1884, at the Electrical Exposition in Philadelphia, of which he was the assistant electrical engineer. By 1890 he had made extensive researches into storage batteries, obtaining numerous patents from the results of his work; he also investigated the regeneration of battery solutions. His work on electric furnaces began in 1900 with tests for the reduction of arsenic ores. Some 6 years later, while designing and operating electric furnaces, he discovered the "pinch" effect. He also made other discoveries showing that electromagnetic forces act upon the material of the conductor. In 1909 he applied these forces to impart rapid motion to molten masses and, based upon this principle, he invented an electric furnace in wide commercial use.

Doctor Hering was a voluminous writer, aiming to bridge the gap between pure and applied science. In 1883 he computed conversion factors for electrical and mechanical energy, publishing a comprehensive treatise in 1904; later he recalculated all electrochemical equivalents. In 1892 he was technical editor of the *Electrical World* and in 1893 he established and compiled the "Digest of Electrical Literature."

He served the Institute as committeeman, first local secretary for Philadelphia (1888) and national vice-president (1891–93; 1895–98), standing firmly for the maintenance of Institute ideals throughout the whole period of his membership. He was a founder and president of the American Electrochemical Society and a member of the Franklin Institute, Illuminating Engineering Society, and American Association for the Advancement of Science. He was appointed officer of Public Instruction by the French Government in 1889 and decorated a Knight of the Legion of Honor in 1891. He was a delegate to a number of important national and international conventions.

Charles P. Steinmetz

(A'90, M'91, F'12)

President 1901–02

FOR more than 30 years Charles Proteus Steinmetz was a leader in the electrical industry, devoting his life to research, largely relating to mathematical foundations upon which many of the developments in electrical engineering are based; there was scarcely a detail of any branch of electrical science or mathematics with which he was not conversant. Of his achievements among the most important were his investigations in the field of magnetism and his researches into the theory of direct and alternating current and the phenomena of lighting.

He was born on April 9, 1865 in Breslau, Germany, and was educated at the universities of Breslau and Berlin, and the Polytechnic in Zurich, Switzerland, specializing in mathematics, electrical engineering and chemistry, and teaching mathematics at the same time. At 24, he left Germany because his socialistic affiliations barred him from preferment, and came to the United States practically penniless and knowing almost no English. Later he was naturalized, and became interested in politics in Schenectady. During a Socialist regime he was appointed president of the board of education of that city in 1912 and held the position throughout succeeding administrations until his death on October 26, 1923.

The first job he obtained was as draftsman at the Osterheld and Eickemeyer factory in Yonkers, N. Y.; soon he was given charge of all the new and experimental work in the establishment. Besides working on inventions for electric motors and generators and electric street cars, Doctor Steinmetz attracted attention by articles he contributed to scientific papers here and in Germany, especially on the theory of alternating currents. He was put in charge of the research laboratory and began to specialize on magnetic testing. In 1892, the firm merged with the General Electric Company and he was sent to Lynn, Mass.; the next year he was transferred to Schenectady as chief consulting engineer, remaining in that position until his death. In 1902 he became also professor of electrophysics at Union University.

He possessed a marvelous insight into all scientific phenomena and an unequaled ability to explain the most difficult and abstruse problems by systematic mathematical methods. He expressed his desire to communicate his fundamental knowledge to others in the stimulating instruction he gave to his assistants at the General Electric and in the publication of a large number of scientific papers and electrical books, which have long been accepted as standard textbooks in colleges, laboratories, and workshops.

Doctor Steinmetz served the Institute as vice-president (1896–98), manager (1892–95; 1898–1901) and as committeeman at various times; he also contributed papers frequently to Institute meetings and publications, his first, in 1892, "On the Law of Hysteresis," marking a new epoch in electrical science. He was a member of numerous scientific and educational organizations. He received 2 honorary degrees, the A.M. from Harvard (1902) and Ph.D. from Union (1903).

Charles F. Scott

(A '92, M '93, F '25, member for life)

President 1902–03
Honorary Member 1929
Edison Medalist 1929

DURING his long and active career Charles Felton Scott has been an outstanding figure in both the engineering and educational fields, a meritorious inventor, a frequent contributor to the literature and a self-sacrificing worker for the benefit of the electrical engineering profession.

Prof. Scott was born at Athens, Ohio, in 1864, and attended Ohio University in Athens, and graduated from Ohio State University with the A.B. degree in 1885. He took postgraduate courses at Johns Hopkins University and received the honorary degrees of M.A. from Yale University, Sc.D. from the University of Pittsburgh, and Engg.D. from Stevens Institute of Technology.

He is perhaps most widely known as the inventor, in 1894, of the "Scott connection" by which 2 transformers are T-connected to change 2-phase alternating current to 3-phase and vice versa. He was closely identified with early single-phase railway electrifications, including the New York, New Haven, and Hartford. He had charge of the design of the transformers for the first high-voltage transmission system in this country, and was connected with the original Telluride installation. In the development of the polyphase induction motor he was associated with Nikola Tesla and was responsible for certain parts of the work. He was early identified with the problem of inductive coördination.

Professor Scott began as a wireman at the Baldwin Locomotive Works, going to the Westinghouse Electric and Manufacturing Company in 1888 as night testing room assistant; in 1891 he became assistant electrician, in 1897 chief electrician and finally, in 1904, consulting engineer. He initiated the Westinghouse Club and the *Electric Journal*. In 1911 he accepted the professorship of electrical engineering at Sheffield Scientific School, Yale University, where he was active head of the department until 1933, when he became professor of electrical engineering emeritus.

He has given enthusiastic service to the profession and in particular to the Institute. As its president he instituted an active campaign for members, founded the high-voltage transmission committee, stimulated Section growth and established Student Branches. He advocated a building for many engineering societies instead of one for the Institute only and was instrumental in securing funds for the Engineering Societies Building. He was chairman of the building committee and a charter member of United Engineering Society; he served on the Institute development committee in 1919 and on the committee which formed the American Engineering Council.

During 1921–23 he was president of the Society for the Promotion of Engineering Education; he proposed and was active in undertaking a study of engineering education. This work has been an important achievement and contribution to the profession. He also took an active part in organizing the Summer Conferences for Engineering Teachers 1927–33. He is a member of The American Society of Mechanical Engineers, Illuminating Engineering Society, Connecticut Society of Civil Engineers, American Philosophical Society, and Engineers Society of Western Pennsylvania, of which he was president 1902.

Bion J. Arnold

(A '92, M '93, F '12, member for life)

President 1903–04

THROUGHOUT the long and eminently successful career of Bion Joseph Arnold, his initiative, ingenuity and resourcefulness have been recognized not only by his fellow engineers, but also by the general public who know him well for his inventions, extensive consulting practice and the installation and direction of numerous public utility services.

He was born at Casnovia, Mich., in 1861, and was educated in the Ashland, Neb., public schools, the University of Nebraska and at Hillsdale College, Mich. He received the degrees B.S. from Hillsdale, 1884, and M.E., 1887; later he took a postgraduate course in electrical engineering at Cornell, and in 1897 he received the degree E.E. from the University of Nebraska, and, at various times, many honorary degrees.

In his boyhood Col. Arnold constructed models of farm implements, a steam engine, steam plant, bicycle and, most remarkable a working model of the standard Burlington locomotive, complete in all details and $^{1}/_{16}$ full size. The locomotives which entranced him as a child drew his interest as a young man to the railroad and its problems. Fame first came to him in 1893 by the design and building of the Intramural Elevated Railway at the Columbian Exposition, in Chicago. This was the first commercial installation of the third rail on a large scale, and it led to a wide practice as consulting engineer for steam and electric railways. Later he did the pioneer work of installation for such roads as the Chicago, Milwaukee Electric Railway, and the Lansing, St. Johns and St. Louis Railway, in Michigan. For the latter he developed in 1900 an a-c single-phase system. He converted from steam to electrical operation the Grand Trunk Railroad through the St. Clair Tunnel from Port Huron, Mich., to Sarnia, Ont. The single-phase high-voltage system for heavy electric railway work was adopted here for the first time.

Other important commissions Col. Arnold carried out where the development of the electrification of the Grand Central Terminal, New York, and the development of the subway system of New York. He has been consultant on surface and underground traction matters at various times for cities all over the country, and consulting engineer for numerous railroad commissions. He now maintains headquarters at Chicago.

During the war, Col. Arnold served in various capacities, being assigned as Lieut. Col., Aviation Section, 1917, to make a complete survey of aircraft supply and production conditions for the Army and Navy, and to take charge of the development and production of aerial torpedoes. His most recent commission is Col. Auxiliary Corps, 1925, which he now holds. Col. Arnold has served the Institute on various committees and is a member of numerous other societies, among them, the American Society of Civil Engineers, The American Society of Mechanical Engineers, Western Society of Engineers, and American Society for Promotion of Engineering Education.

John W. Lieb

(A '87, M '92, F '13, member for life)

President 1904–05

Edison Medalist 1923

THE INSTITUTE'S Edison medal for 1923 was awarded John William Lieb "for the development and operation of electric central stations for illumination and power." That phrase well summarizes the guiding influence in Mr. Lieb's life.

He was born in Newark, N. J., in 1860, and graduated from Stevens Institute of Technology in 1880. In 1921 he received the honorary degree of doctor of engineering from that institution. Upon graduation he entered the employ of the Brush Electric Company, Cleveland, Ohio, but in 1881 transferred to the Edison Electric Light Company of New York, becoming assistant in the engineering department. The following year he became assistant to Mr. Edison and was engaged in experimental research, working with Mr. Edison in tests on the now famous Pearl Street station. In 1882 he was appointed the first electrician of the company.

In 1883 he went to Milan, Italy, to represent Mr. Edison in connection with the design, installation, and operation of the Milan Central Station. He later became technical director of the Società Generale Italiana di Elettricita Sistema Edison, and for his work in introducing the use of

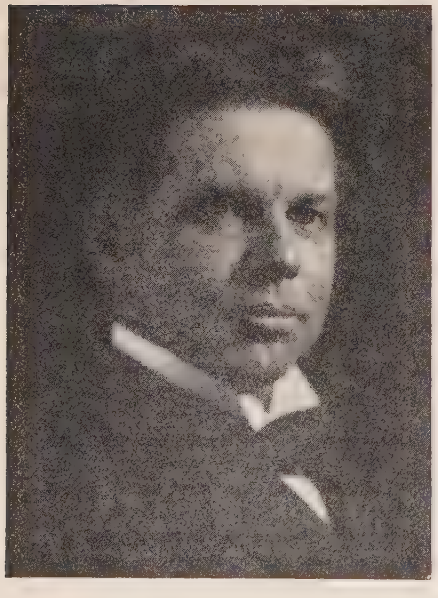
electricity into Italy, was made Knight Commander of the Royal Order of the Crown of Italy, in which he was later promoted to a Grand Officer. He was also made an officer of the French Legion of Honor.

In 1892 Mr. Lieb returned to New York as assistant to the vice-president of the Edison Electric Illuminating Company. He was later made vice-president and general manager of the company, and when the New York Edison Company was organized he became associate general manager and then appointed vice-president in general charge of operations. He later became general manager and upon the consolidation of the New York Edison Company with other utility companies in the New York Metropolitan area in 1928, Mr. Lieb became senior vice-president. He held this position at the time of his death, November 1, 1929.

For many years following 1900, Mr. Lieb also was president of the Electrical Testing Laboratories of New York. Mr. Lieb held office in several other utility companies. During the war, Mr. Lieb rendered valuable service as chairman of the national committee on gas and electric service.

Mr. Lieb took a prominent part in the work of many of the organizations in the electrical and allied field. He was a past-president of several such organizations. For the Institute, he has served on several committees as well as holding the presidency for one year. His work was recognized by many foreign societies and he was a member or honorary member of several of these.

Beside taking a part in the deliberations of foreign societies (he spoke 4 languages fluently) Mr. Lieb was an outstanding figure in the promotion of amity, peace, and good-will among the technical and engineering men of the world.



Schuyler Skaats Wheeler

(A '85, M '85, F '12, Life Member)

President 1905–06

THE presentation to the Institute by Schuyler Skaats Wheeler of the Latimer Clark Library in 1900, is of itself sufficient to insure Doctor Wheeler a permanent place in the rôle of those who have given outstanding service to the Institute. This act, however, was but one of the many contributions which he made. During the early development of the industry, he was responsible for many inventions and applications of electrical equipment.

Doctor Wheeler was born in New York, N. Y., May 17, 1860. He was educated at Columbia College, and was awarded the honorary degree of doctor of science by Hobart College in 1894, and that of master of science by Columbia in 1912. At the age of 21 he left college to become assistant electrician of the Jablochkoff Electric Light Company, and in 1882 joined the engineering staff of Thomas A. Edison, in charge of work at the first power station. He was in this position in 1893 when the incandescent light was introduced. He installed and operated several other stations during the next 2 or 3 years.

In 1886 he left the Edision Company and became connected with the C. & C. Electric Motor Company, which, with Charles G. Curtis and Francis B. Crocker, he helped to organize. They were the pioneer manufacturers of small electric motors.

In 1888 the firm of Crocker & Wheeler was organized, which shortly was incorporated as the Crocker-Wheeler Motor Company, of New York, and subsequently became the Crocker-Wheeler Company, of Ampere, N. J. Doctor Wheeler was the president of this concern from 1888 until the time of his death in 1923. During the many years that he was active head of the company, he was particularly prominent in development of the electric motor and its application to machine tool drives.

Doctor Wheeler was electrical expert for the Board of Electrical Control of New York from 1888 until 1895. He was the inventor of many electrical and mechanical devices, such as the electric elevator, electric fire engine, series multiple motor control, and paralleling of dynamos. In 1904 he received the John Scott Medal of the Franklin Institute for the invention of the electric fan in 1886. Doctor Wheeler was 1 of the 9 incorporators of the United Engineering Society in May 1904, being 1 of the 3 representatives of the Institute. The Latimer Clark Library, which Doctor Wheeler purchased in London in 1900 had been owned by the late Latimer Clark and was the largest collection of rare electrical works in existence. Doctor Wheeler presented this library to the Institute, thus forming the foundation of the electrical section of the large library now housed in the Engineering Societies Building in New York.

It was from the presidential address of Doctor Wheeler in Milwaukee in 1906 that the ideas were taken for the "code of ethics" for electrical engineers finally adopted by the Institute's board of directors in 1912. Among the many committees on which he served was the committee on code of principles of professional conduct of which he was chairman at the time of his death. Doctor Wheeler had served the Institute as manager from 1887 until 1904, and also in 1904–05; he had served 3 years as a vice-president.

Samuel Sheldon

(A '90, M '91, F '13, Life Member)

President 1906–07

ONE OF the foremost educators in the engineering profession, Dr. Samuel Sheldon, was enthusiastic in his devotion to the advancement of the electrical engineering profession, and in his unbounded faith in the future importance of the Institute. His unfailing support of every movement looking to the logical position of the Institute as the exponent of the highest standards of the electrical art, marked his development as a leader, not only with confidence in himself, but thoroughly appreciative of the work of his associates.

Doctor Sheldon was born in Middlebury, Vt., on March 8, 1862, graduating from Middlebury College in 1883, and remaining there 2 years as instructor in mathematics; he received the degree of A.M. there in 1886. In 1888 he received the degree of Ph.D. at Wurzburg, Germany. During part of this time he was associated with Kohlrausch, the distinguished physicist, in the determination of the ohm as a unit of electric resistance. He was awarded the honorary degree of doctor of science from the University of Pennsylvania in 1906, and from Middlebury College in 1911.

Doctor Sheldon went to the Polytechnic Institute of Brooklyn, N. Y., in 1889, after a year spent at Harvard University as instructor of physics, and was immediately honored with a full professorship in physics and electrical engineering in the newly organized department of electrical engineering. Although only 27 years old, he had a thorough command of his subjects, together with enthusiasm and energy, which he exhibited in the lecture rooms. In addition to having an analytical mind, he had an inspiring and sympathetic personality, which made him valued as a teacher. Under his supervision the shop, mechanical engineering, physical and electrical engineering laboratories were installed. Illness in 1909 necessitated a long vacation which he spent mostly in Europe, where he had an opportunity to visit the principal engineering schools. He returned to the Polytechnic Institute of Brooklyn, and was professor of physics and electrical engineering until the time of his death, September 4, 1920.

Doctor Sheldon was frequently called upon to give testimony in both the state and federal courts, and for many years following 1903 was an expert of the Swiss Department of Justice and Police. He also carried on an extensive consulting engineering practice in all branches of engineering.

He served the Institute as manager for 6 years, and vice-president for 2 years, in addition to holding the presidency. He had been chairman of the papers committee, 1902–06; chairman of the standards committee, 1907–08; chairman of the library committee for a number of years following 1910, besides serving on various other committees.

Dr. Sheldon was a past-president of the New York Electrical Society and a member or fellow of a number of other technical and scientific societies. He was the author and joint author of several college text books, had written a number of papers on various topics, and contributed extensively to encyclopedias and engineering handbooks. For several years following 1900 he was editorial critic for a publisher of technical books.

Henry G. Stott

(A '95, M '96, F '12)

President 1907–08

HENRY GORDON STOTT was for many years active in the design, construction, and operation of the power systems supplying subway, elevated, and surface lines of New York City. He was also a firm believer in coöperation among engineers, through the agency of engineering societies, and devoted much of his time and ability to the welfare and development of these professional organizations.

He was born at Stennis, in the Orkney Islands, Scotland, May 13, 1866. After preliminary study he was a student at the Watson Collegiate School, Edinburgh, and then entered the college of Arts and Sciences at Glasgow, graduating in 1885 from a course in mechanical engineering and electricity. In the previous year he had entered the employ of the Electric Illuminating Company of Glasgow. Upon graduation he was assistant electrician on the S.S. "Minia," belonging to the Anglo-American Telegraph Company, and for $4^1/_2$ years saw much service in connection with repairs to telegraph cable lines.

In 1889 Mr. Stott was made assistant engineer of the Brush Electric Engineering Company plant at Bournemouth, England. The following year he became assistant engineer in the construction of underground cable and power plants at Madrid, Spain, for Hammond and Company.

In 1891 he came to the United States to install an underground cable and conduit system at Buffalo, N. Y., for what was then the Buffalo Light and Power Company, becoming engineer of the company shortly thereafter. From that time until 1901 he was one of the most active figures in the industrial progress of Buffalo.

In 1901 he was appointed superintendent of motive power for the company which later became the Interborough Rapid Transit Company, of New York City. Before starting actual work, it was necessary for him to organize an operating force. In 1904 he undertook the construction of a power plant for the Interborough Rapid Transit Company, and from that time until his death on January 15, 1917, he was in charge of the design, construction, and operation of the power generating stations and the distributing system of the Interborough.

Mr. Stott served the Institute as a member of the board of directors for 3 years preceding his presidency, and was a member of a number of the Institute's committees. He served as a vice-president of The American Society of Mechanical Engineers, 1912–14, director of the American Society of Civil Engineers, 1911, and was vice-president and trustee of United Engineering Society at the time of his death.

Mr. Stott was known for his minute analysis of engineering problems, and he had passed his information on to others through the presenting of a number of papers before the Institute and other societies.

Mr. Stott was a remarkable figure in the engineering world because he was in the front rank of both electrical and mechanical engineers, because in both branches of the art, he was a master of theory and practice, and because with these technical qualifications he combined a rare executive ability, a power of inspiring the confidence of his employees and of bringing out the best that was in the men who worked for him.

Louis A. Ferguson

(A '01, M '04, F '12)

President 1908–09

THE life of Louis Aloysius Ferguson has been intimately connected with the tremendous growth of the electric light and power industry. When he entered the service of the Chicago Edison Company, now the Commonwealth Edison Company, Chicago, the original Adams Street station of this company with its 4 200-hp noncondensing engines and belted d-c generators was just nearing completion. Today, Mr. Ferguson is vice-president of the company, and its combined generating capacity is over 1,000,000 kw.

Mr. Ferguson was born in Dorchester, Mass., August 19, 1867. In 1888 he graduated from the electrical engineering course at Massachusetts Institute of Technology, Cambridge, with the degree of B.S. From there he went directly to the underground distribution department of the Chicago Edison Company.

In 1890 he was appointed electrical engineer in charge of all electrical engineering and electrical construction work of the company. Three years later he undertook, in addition, the supervision of all soliciting and contract work, in which field he was especially successful in conducting negotiations with large mercantile and industrial establishments. In 1897 he was appointed general superintendent of the Chicago Electric Company and a year later was given the same position in the Commonwealth Edison Company; supervision of the operating departments of the company was added to his duties. In 1902 he was elected second vice-president of both companies, in charge of contracts, operating, construction, and electrical departments. In 1907 he was elected second vice-president of the Commonwealth Edison Company, and since 1914 has been vice-president of this company.

Mr. Ferguson early recommended adoption of the 3-phase a-c system of transmission to substations, with rotary conversion to direct current for general distribution. He has made notable contributions to the development of low voltage distribution. He has kept in close touch with European engineering developments through frequent trips and has applied his findings to the Chicago system. Also, he has much to do with the development of rate structures as used in the United States.

Mr. Ferguson has served the Institute as manager, 1904–07, vice-president 1907–08, and as president. He also has been a member of the Edison Medal committee, board of award of the John Fritz medal, the committee of the Washington Award, and chairman of the executive committee. He is a past-president of the former National Electric Light Association and of the Association of Edison Illuminating Companies.

Lewis B. Stillwell

(A '92, M '92, F '12, member for life)

President 1909–10

Lamme Medalist 1933

THE INSTITUTE'S Lamme Medal for 1933 is to be presented at the 1934 summer convention to Dr. Lewis Buckley Stillwell "for his distinguished career in connection with the design, installation, and operation of electrical machinery and equipment." This distinguished career extends over a period of nearly 50 years, and includes not only the development of a number of pieces of electrical equipment used in the early days of the industry, but the supervision of an impressive list of modern installations, particularly in railway electrification.

Doctor Stillwell was born at Scranton, Pa., in 1863. He was a student in the Latin scientific course at Wesleyan University, Middletown, Conn., 1882–84, and took a special course in electrical engineering at Lehigh University, Bethlehem, Pa. In 1885 he received the degree of electrical engineer from Lehigh University. He also has received the honorary degrees of master of science, Lehigh University, 1907; doctor of science, Wesleyan University, 1907; and doctor of science, Lehigh University, 1914.

From 1886 to 1891, he was employed as assistant electrician of the Westinghouse Electric and Manufacturing Company, and served as chief electrical engineer of that company from 1891 to 1897. He was an outstanding leader in the development of alternating current, and invented the "Stillwell regulator" for the adjustment of voltage on outgoing lines. Two other inventions which he made and which today are more important, are the "time limit circuit breaker" and the "diagrammatic pilot-control switchboard."

His contributions, as Westinghouse engineer, to the general layout and design of the first plant of the Niagara Falls Power Company led to his appointment as electrical director of the latter company, which position he held from 1897 to 1900.

Doctor Stillwell began his practice as a consulting engineer in New York City in 1900, and has filled engagements with many companies on large and important engineering projects, including: the electrification of the elevated lines of the Manhattan Elevated Railway Company, 1900–06; Rapid Transit Subway Construction Company, 1900–09; Wilkes-Barre and Hazleton Railway, 1902–05; Hudson and Manhattan Railroad, 1905–13; Erie Railroad electrification, 1906; United Railways and Electric Company of Baltimore, Md., 1906–20; Interborough Rapid Transit Company, 1909–20; electrification of the Hoosac Tunnel of the New York, New Haven, and Hartford Railway Company, 1910–11; New York, Westchester, and Boston Railway Company, 1911–15; Lehigh Coal and Navigation Company, 1912–18; New York Municipal Railway Corporation, 1913–16; board of economics and engineering of the National Association of Owners of Railroad Securities, 1921–22; Holland vehicular tunnel, 1924–27; and Port of New York Authority since 1927.

Doctor Stillwell has served on many of the most important Institute committees, including the executive, code of principles of professional conduct, public policy (now Institute policy) Edison medal, standards, and board of examiners. He also has represented the Institute on the assembly of the American Engineering Council, the Engineering Foundation Board, John Fritz Medal board of award, and the coördination committee of engineering societies. He was a director of the Institute 1896–99, a vice-president 1899–1901, and the president 1909–10. He was vice-president of the American Engineering Council for 4 years, 1930–33, inclusive. He is the author of several important Institute papers. Doctor Stillwell has received a number of awards.

Dugald C. Jackson

(A '87, M '90, F '12, member for life)

President 1910–11

THROUGHOUT almost the entire history of the Institute, Dugald Caleb Jackson has been an active member of the profession, as an engineering educator and as consulting engineer.

He was born at Kennett Square, Pa., February 13, 1865. In 1885, one year after the founding of the Institute, he graduated from Pennsylvania State College with the degree of C.E. He then devoted 2 years to postgraduate study in electrical engineering at Cornell College, serving as instructor in physics in 1887.

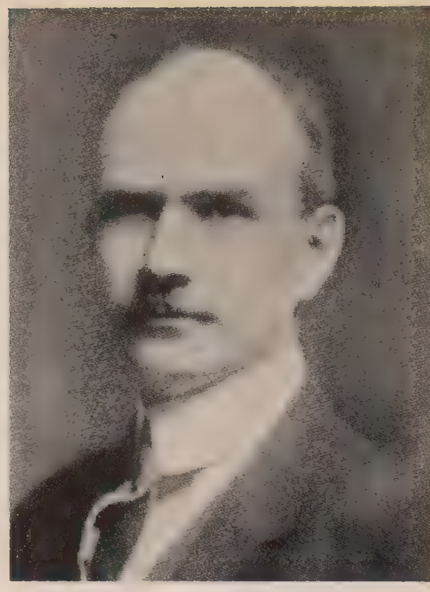
For the next 2 years he was vice-president and engineer for the Western Engineering Company at Lincoln, Neb., engaged in the design and construction of electric light and power plants and distribution systems in that part of the country. Throughout the years 1889–90 he served as assistant chief engineer with the Sprague Electric Railway and Motor Company, at New York, and for the following year was chief engineer of the central district of what was then the Edison General Electric Company. In these 2 positions he supervised the design and construction of many electric railway and power plants.

In 1891 he became a member of the firm of D. C. and Wm. B. Jackson, consulting engineers; also professor of electrical engineering at the University of Wisconsin. He remained at Wisconsin for 16 years, developing the department of electrical engineering, until, in 1907, he became professor of electrical engineering at the Massachusetts Institute of Technology, and head of its electrical engineering department. Professor Jackson still holds this position.

Professor Jackson continued as a member of the firm of D. C. and Wm. B. Jackson, until the firm of Jackson and Moreland was formed shortly after the War. He continued as the senior member until 1930. The firm has been particularly active in railway electrification.

Professor Jackson has given freely of his time to the Institute, having served on 16 of its committees, chairman of 3 of these, and a representative of the Institute on 3 other groups. He was vice-president 1897–99, and president.

During the World War, Professor Jackson served overseas as Lieut.-Col. of Engineers. He was a member of jury of electrical awards at the World's Columbian Exposition, Chicago, 1893, and at the Pan-American Exposition, Buffalo, 1901. In 1929 he was U.S. Government delegation to the World Engineering Congress. He is a chevalier of the French Legion of Honor. He is a past-president of the Society for Promotion of Engineering Education (recipient of its 1931



Lamme Medal), and of the Boston Society of Civil Engineers, as well as being a member or fellow of a number of other technical societies in this and other countries. He is the inventor of a number of electrical devices, as well as author of many technical papers and books on engineering subjects and on engineering education.

Gano Dunn

(A '91, M '94, F '12, Life Member)

President 1911–12

STRAIGHT thinking, combined with a sympathetic nature and a charming personality, has done much to account for the leadership of Gano Dunn. As an engineer he has made many original contributions to electrical design and application. As an executive he has led organizations with resourcefulness. In addition, he has given freely of his time to Institute activities in order that greater progress could be made by the entire profession.

Mr. Dunn was born in New York City, October 18, 1870. He attended the College of the City of New York, from which he graduated with the B.S. degree in 1889; he also received the degree of M.S. from that institution in 1897. In 1891 he received the E.E. degree from Columbia University, and the honorary M.S. degree from Columbia in 1914.

His professional work began in 1886, in the service of the Western Union Telegraph Company, where he remained 5 years. He then entered the service of the Crocker-Wheeler Company at Ampere, N. J., and from 1898 until 1911 was vice-president and chief engineer of that company. In the latter year he was elected vice-president in charge of engineering and construction of J. G. White & Company, and in 1913, when the J. G. White Engineering Company was organized to take over the engineering and

construction work of the parent company, Mr. Dunn was made president, which position he still holds.

While with the Crocker-Wheeler Co., Mr. Dunn did much to build up this company from a small organization to a large manufacturing concern. Also, many patents were granted him on generators, motors, rheostats, switches, and on systems of operation, control, and regulation. Since joining J. G. White & Co. in 1911, he had been responsible for the design, construction, and operation of many public utility properties, including hydroelectric developments, central lighting and power stations, electric and steam railways, and other services throughout the world.

Mr. Dunn is the author of numerous papers on engineering subjects. He has served the Institute on 12 of its committees and has been the Institute's representative on 9 other bodies. He has also served as manager 1897–1900 and 1902–05; and as vice-president 1900–02 and 1905–07.

From 1900–02, Mr. Dunn was president of the New York Electrical Society. He was president of the United Engineering Societies from 1913 to 1916; of the John Fritz Medal Board of Award in 1914; the Engineering Foundation 1915–16, and vice-chairman of the National Research Council 1917, afterward becoming chairman.

He was secretary of electric lighting and distribution for the International Electrical Congress, St. Louis, 1904, and vice-president of the International Congress at Turin, 1911. In 1916–18 was a member of the engineering committee of the Council of National Defence, and during the war was chairman of the State department committee on submarine cables.

Among the numerous engineering and scientific societies of which Mr. Dunn is a member are the Franklin Institute, American Society of Civil Engineers, The American Society of Mechanical Engineers, Institution of Electrical Engineers (Great Britain), and the Institute of Radio Engineers.

Ralph D. Mershon

(A '95, A '96, M '12, member for life)

President 1912–13

THE outstanding engineering contributions of Ralph Davenport Mershon have been in the field of high voltage transmission, of which he was one of the pioneers some 40 years ago. Since that time he has been responsible for the design and construction of many important generating stations, transmission lines, and substations in different parts of the world.

Mr. Mershon was born in Zanesville, Ohio, July 14, 1868. At the age of 17 he was engaged in railway location and construction for one year. Entering Ohio State University, he graduated in 1890 with the degree of M.E. He was student assistant in physics and electrical engineering during his senior year, and for one year following graduation was assistant instructor in electrical engineering.

During the period of 1891–1900, he was employed by the Westinghouse Electric and Manufacturing Company at East Pittsburgh, Pa., securing experience in all branches of electrical work. The transformers for which the Westinghouse Company received an award at the World's Columbian Exposition, Chicago, 1893, were of his design. In 1896–97 he was in charge of investigations of phenomena which occur between conductors at high voltages, for the

Telluride (Colo.) Power Transmission Company and the Westinghouse Company. These original investigations of ionization and other atmospheric losses were of great importance at that time, and were carried up to 133,000 volts. On a leave of absence from the Westinghouse Company in 1897–98, he was chief engineer for the Colorado Electric Power Company. During 1898–1900, Mr. Mershon was engineer in the New York Office of the Westinghouse company, resigning in 1900 to enter the private practice of consulting electrical and mechanical engineer in New York City, in which capacity he is still active. He has designed and supervised many power plants and transmission systems in the United States, Canada, South Africa, and Japan.

Mr. Mershon has to his credit many inventions, which include the 6-phase rotary converter, the compounded rotary converter, systems of lightning protection for electrical apparatus, and a compensating voltmeter for which he was awarded the John Scott medal of the city of Philadelphia.

Prior to the war, Mr. Mershon was active in the creation of the reserve officers' training corps, and was made a major in this corps in 1917. During the war he was detailed to the Naval Consulting Board, and was Lieut.-Col. of Engineers at the time of his retirement from military service.

Mr. Mershon has served on a number of the Institute's committees, and was manager 1900–03, vice-president 1903–05, and later president. He is a member of other technical societies in the United States, Canada, and England, and is a past-president of the Inventors' Guild. Since 1895, he has been the author of a number of technical papers of importance to the industry. A paper presented in 1897 contained a chart for transmission line calculations, for which he has become widely known. In 1918 Tufts College presented him with the honorary degree of doctor of science.

C. O. Mailloux

(A '84, M '84, F '12, Life Member)

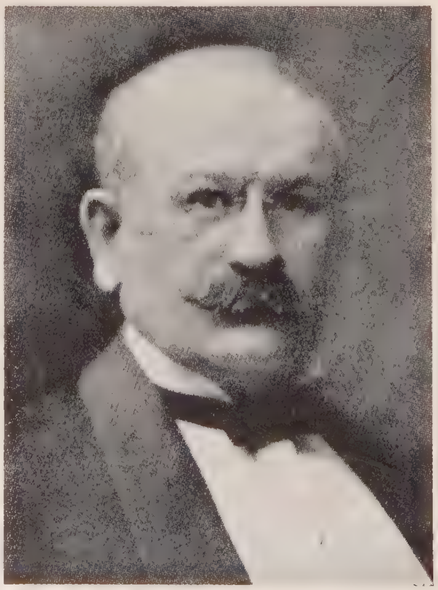
President 1913–14

CYPRIEN O'Dillon Mailloux, a charter member of the Institute and active in its affairs until his death, October 4, 1932, was among that group of pioneers in the industry which laid the foundations of electrical engineering practice and followed its development closely up to recent years.

Doctor Mailloux was born at Lowell, Mass., in 1860. At an early age he went to New York City where, in pursuit of professional learning, he was one of the leading pupils of Dr. M. I. Pupin, at that time a lecturer on advanced theory of electrical engineering at Columbia University.

Following graduation, Doctor Mailloux entered upon his career as a consulting electrical engineer, continuing in this capacity until his death. His application for transfer to the grade of Fellow in 1912 gives some idea of the remarkable range of his activities. This application states that in the preceding period of 25 years he had the direction of electrical work in over 800 jobs, ranging from 50 to 25,000 kw or more, including special design of apparatus and machinery in hundreds of cases, and that he had made at least 100 original inventions, over 30 of which had been patented. It also was stated that he had done expert work, and submitted testimony, reports, and arbitrations in over 1,000 cases, and had published several dozen original papers and articles.

In addition to having been president, Doctor Mailloux served the Institute as manager 1886–89, 1905–07, and 1899–1902. He also had served as vice-president 1898–99 and 1902–04. He had served on 5 of the Institute's committees, and been a representative of the Institute on 3 other bodies.



Doctor Mailloux was particularly active on the International Electrotechnical Commission, and on the U.S. national committee of this organization. For the U.S. national committee of the I.E.C. he had served as president 1914–24, chairman of the advisors on nomenclature, representative of the National Research Council on the division of foreign relations, and honorary president. For the I.E.C., he had been president 1919–23, director of the secretariat on nomenclature, and at the time of his death, honorary president. For the international conference on large electric high-tension systems, he had served as honorary president, acting also as United States delegate at recent biennial meetings.

Doctor Mailloux had been a chevalier of the French Legion of Honor. He also had received honors in this country, included in which was the degree of D.Sc., from Lehigh University in 1914.

Doctor Mailloux was a former editor of the *Electrical World*, having served during the early part of his career, and continued to be a liberal contributor to technical literature throughout his life. Largely through his efforts the electrical engineering nucleus of the present Engineering Society's library in New York had its origin. In 1903–04, he donated several volumes and subscriptions to technical periodicals to the library.

He had been for many years an advocate of the use of a universal language to standardize technical terms throughout the world.

Paul M. Lincoln

(A'95, M'98, F'12, member for life)

President 1914–15

ONE of the most prominent engineers and educators in the electrical engineering industry is Paul Martyn Lincoln, director of the school of electrical engineering at Cornell University.

He was born in Norwood, Mich., January 1, 1870, and was educated at Western Reserve and at Ohio State universities, receiving from the latter the M.E. degree in electrical engineering in 1892. He was employed first as testing electrician by the Brush Electric Company, doing some drafting later. The next year, in 1893, he went to the Pittsburgh plant of the Westinghouse Electric and Manufacturing Company, where he took the training course of the company. In 1895 he was chosen for the position of electrical superintendent in charge of water power development of Niagara Falls. Hydroelectric development was in the early stages then, and the amount of power generated, transmitted, and distributed by this first plant was so far in excess of anything accomplished up to that date that it was unique; Mr. Lincoln's responsibilities were considerable as he had charge of the operating department. In

1902 he returned to Westinghouse in Pittsburgh and was in charge of the power division of the engineering department for 6 years. He was appointed general engineer for the company in 1910, holding that position until 1919. At that time he resigned from his position with Westinghouse to join the firm of his older brother, the Lincoln Electric Company, as consulting engineer. From 1911 to 1915 he was head of the electrical school at the University of Pittsburgh, and from 1922 to date he has been director of the school of engineering at Cornell University.

In 1902 he received the John Scott medal award from the City of Philadelphia, upon the recommendation of the Franklin Institute, for his invention of the synchroscope, a device now in universal use wherever a-c machines are paralleled.

Mr. Lincoln has served the Institute as manager (1906–09) and as vice-president (1909–11). He has been very active on Institute committees, serving on the papers, and meetings and papers (now technical program) committees, on the executive, Sections and law committees, and on many technical committees, as, power stations, protective devices, transmission and distribution, electrical machinery, standards, instruments and measurements, etc. He has served on the board of award of the John Fritz medal, and at present is serving on the Edison and Lamme medal committees. He was a member of the board of management of the World's Congress of Engineers, 1923–25. He is a member of several scientific and engineering societies in the United States.

John J. Carty

(A'90, M'03, F'13, member for life)

President 1915–16
Honorary Member 1928
Edison Medalist 1917
John Fritz Medalist 1928

BECAUSE of his innumerable contributions to the art of telephony, John Joseph Carty ranked from the pioneer days of the telephone until his death in 1932 as one of the world's foremost telephone engineers. He was a prolific inventor and a skilful organizer of the inventive genius of others. Three of his early achievements are fundamental and necessary today: the invention of the "common battery," development of the high resistance bridging signal bell for subscribers' substations, and the discovery that the principal cause of cross interference between telephone circuits was electrostatic rather than electromagnetic unbalance. The accomplishments of his later life and for which he is best known in the field of electrical communication are those of a generalissimo—the organization and direction of long distance telephony over land, transoceanic radio telephony and coördination of the maze of factors which make telephony today so marvelously easy.

General Carty was born in Cambridge, Mass., April 14, 1861. He was obliged to forego a formal higher education because of a temporary impairment of vision. His tremendous knowledge he secured through original research, experience, scientific reading and, as he expressed it, "asking questions." In 1879, when he was 18 he entered the employ of the Telephone Dispatch Company of Boston. There he designed and installed the first metallic circuit multiple switchboard to be put into service.

In 1887 he was transferred to New York and placed in charge of cable manufacturing for the Western Electric Company in the East and later in charge of switchboard development and manufacture, making a number of improvements in the design and installation of cables and switchboards.

Two years later he went to the New York Telephone Company as electrician; later he became chief engineer. Under his direction the New York City telephone plant was converted from open wire to cable, and from the local battery switchboard system to the common battery system.

He was chief engineer of the American Telephone and Telegraph Company from 1906 to 1909, when he was elected vice-president. He consolidated all the laboratories and experimental work into a single organization known now as the Bell Telephone Laboratories. Under his leadership the transcontinental telephone line was completed in 1915; a successful demonstration of wireless telephony was made and the underground cable system from Washington to Boston was completed. In 1925 he became chairman of the board of directors of the organization, retiring in 1930, about 2 years before his death on December 27, 1932.

When the United States entered the war General Carty was a major in the signal corps reserve; he organized the research and inspection division for the chief signal officer of the American Expeditionary Forces. He was responsible for the maintenance of transatlantic communication between General Pershing and Washington and directed the construction of a long distance telephone system covering most of France. In 1918 he was promoted to colonel and ordered to France as chief signal officer. After the Armistice he was placed in charge of communications for the American Commission to Negotiate Peace. Later he was made Brigadier General and still later, General. He received the Cross of the Legion of Honor of France.

H. W. Buck

(A'95, M'01, F'12, member for life)

President 1916–17

THE engineering achievements of Harold Winthrop Buck have been principally in the field of construction of public utility properties. As an electrical engineer in charge of design and construction, in the earlier period of his career, and more recently as an executive of the corporation of Viele, Blackwell and Buck, consulting engineers, New York City, he has been identified with many important enterprises in the development of electric power.

Mr. Buck was born in New York City, May 7, 1873. In 1894 he graduated from Yale University with the degree of Ph.B., and received the degree of E.E. from Columbia School of Mines in 1895. The year 1895–96 was spent as a student in the shops of the General Electric Company at Schenectady, N. Y., most of this time being spent on experimental work on a-c apparatus for Dr. C. P. Steinmetz.

From 1896 to 1900, Mr. Buck was assistant to the chief engineer of the lighting department of the General Electric Company, Schenectady, in which capacity he had much to do with the introduction of high-voltage a-c distribution in many parts of the United States. During that same period, he also had charge of much experimental work leading to the development of the oil circuit breaker and other high-voltage devices.

In 1900 he was chosen chief electrical engineer of the Niagara Falls Power Company and allied interests at Niagara, having entire charge of electrical engineering in the design and construction of power house No. 2 on the American side of the Falls, and the Canadian Niagara Power Company's plant on the Canadian side; also the terminal stations at Buffalo, and engineering in connection with the distribution of power in Niagara, Tonawanda, and Buffalo.

In 1906, in coöperation with E. M. Hewlett, at Niagara Falls, Mr. Buck carried on experimental work on high voltage insulators which had much to do with the development of the suspension insulators now in universal use.

Since 1908 Mr. Buck has been vice-president of Viele, Blackwell and Buck, engaged in the design and construction of hydroelectric and steam power plants and of transmission systems in the United States and Canada. In 1925 the International Commission made him consulting engineer on the investigation of the development of some 4,000,000 hp at various sites on the St. Lawrence River between Ogdensburg and Montreal.

Mr. Buck has presented a number of papers before the Institute and other organizations. In addition to serving the Institute as president, he was manager 1907–10, and vice-president 1910–12. He has served on 7 of the Institute committees, as well as having been its representative on 3 other organizations. His longest term of service was on the Institute's committee on public policy (now Institute policy) on which he served continuously from 1914 to 1929, with the exception of one year. Mr. Buck is a member of the Franklin Institute, the American Electrochemical Society, and the Engineering Institute of Canada.

E. W. Rice, Jr.

(A'87, M'88, F'13, member for life)

President 1917–18

Honorary Member 1933

Edison Medalist 1931

FOR "his contribution to the development of electrical systems and apparatus, and for his encouragement of scientific research in industry," the Institute's Edison Medal for 1931 was presented to Dr. Edwin Wilber Rice, Jr. Doctor Rice is one of the pioneers in electrical development in the United States, and has played a conspicuous part in the building up of the General Electric Company, of which he is now honorary chairman of the board.

He was born at La Crosse, Wis., May 6, 1862. As a school boy in Philadelphia, he came in contact in 1876 with Prof. Elihu Thomson, then a young teacher in the Boys' Central High School. When, in 1880, Professor Thomson gave up teaching to go into electrical manufacturing as scientist and inventor, young Rice gladly accepted the opportunity to become his assistant.

He went with Thomson to New Britain, Conn., in the old American Electric Company, and in 1883 went with the professor to Lynn, Mass., upon the organization of the Thomson-Houston Electric Company. At the age of 22 he was made plant superintendent and had full responsibility until the consolidation of the Thomson-Houston Electric Company and the Edison General Electric Company in 1892, under the name of the General Electric Company.

In the new company, Doctor Rice was first made technical director, then vice-president in charge of manufacturing and engineering. He eventually became senior vice-president, and, in 1913, he succeeded Charles A. Coffin as president of the company. In 1922, after 9 years' service in that office, he was succeeded by Girard Swope. Doctor Rice at that time was made honorary chairman of the board, which position he still holds.

He has contributed much, through organization methods, improved factory routine, technical development, and engineering and scientific inventions, to the preëminence attained by the General Electric Company.

His degrees are: honorary A.M., Harvard, 1903; Sc.D., Union College, 1906; doctor of engineering, Rensselaer Polytechnic Institute, 1917; Sc.D., University of Pennsylvania, 1924. Doctor Rice is a chevalier of the Legion of Honor of France. In 1917 he was decorated by the Emperor of Japan with the Third Order of the Rising Sun with Cordon.

In addition to having been president, Doctor Rice has served the Institute on several committees, and been its representative on numerous other groups. He is now a member of the committee on economic status of the engineer, and a representative on the Hoover Medal board of award.

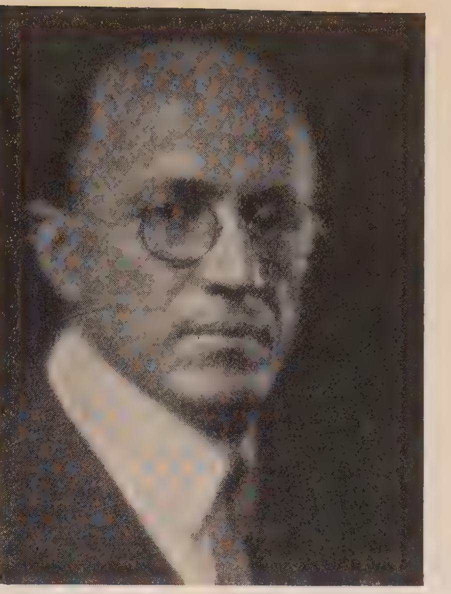
Doctor Rice has taken out over 100 patents, many of these being of great importance to the industry. He was one of the earliest to realize the advantages of scientific research, and it was primarily due to his foresight and guidance that the present research laboratories of the company were built up. In addition to his unusual engineering ability, his ability as a business executive is marked; having been in evidence even during the early years.

Comfort A. Adams

(A'94, M'05, F'13, member for life)

President 1918–19

AMONG the distinguished educators, research engineers, and technical writers on the practice and theory of electrical engineering of today, Comfort Avery Adams takes a prominent place. From his Chair at Harvard University, which he has occupied as Lawrence Professor of Engineering since 1914, he has always shown a keen interest in engineering education, emphasizing not the need for less theory, but for a thorough working foundation in theory. To his mind, the most important problem in the whole field of electrical engineering today is a more thorough understanding of dielectric phenomena in solid and semi-solid dielectrics. He has long been active in the electric welding field.



Professor Adams was born November 1, 1868, in Cleveland, Ohio, and was educated at the Case School of Applied Science. His talent for teaching came to light early in his career, for he assisted Professor A. A. Michelson in the physical laboratory for 3 years during his course. In 1890 he was graduated with the B.S. degree. He was a member of the Reid expedition in Alaska during the summer and on his return to Cleveland in the fall he obtained a position as draftsman with the Brush Electric Company. Under Sidney S. Short he took part in the design of the first geerless railway motor. In 1891 he joined the teaching staff of Harvard with which he has been connected since, first as instructor, then as assistant professor (1896–06), professor (1906–16), Lawrence professor of engineering since 1914, dean of the engineering school (1919–21). In 1905 he took the E.E. degree from the graduate school and in 1925 the university bestowed upon him the honorary degree of doctor of engineering.

Professor Adams has carried on an extensive consulting practice, acting at present as consultant for the American Tool and Machine Company of Boston, Okonite Company, Okonite Callender Cable Company, Babcock and Wilcox, and General Electric. He has conducted numerous investigations on a-c commutating machines, leakage reactance of induction motors, etc.

He has served the Institute as manager (1912–15), vice-president (1915–17), and has participated in the activities of many important committees, as chairman and member at various times of the executive committee and the committees on public policy (now Institute policy), code of professional conduct, research, education, and electric machinery. He is now serving on the standards and electric welding committees. He has been active also in the coöperation movement of the engineering societies, taken part in the organization of what is now the American Standards Association, acting as its first chairman. He reorganized the engineering division of the National Research Council after the war, is a charter member of the American Engineering Council and took part in the organization of its predecessor, the Federated American Engineering Societies. He has represented the Institute as member and president of the John Fritz medal award board and served on Edison medal committee.

During the war Professor Adams served as chairman of the general engineering committee of the Edison Commission of the Council of National Defense; chairman of the welding committee of the Emergency Fleet Corporation, and chairman of the electrical engineering section of the National Research Council.

Calvert Townley

(A'01, M'07, F'12)

President 1919–20

AN UNUSUAL combination of engineering skill and managerial ability from the commercial standpoint made Calvert Townley one of the most conspicuous engineers in the railroad and utilities fields. He was a capable technical adviser, executive, and a very able engineer in the practical work of design, construction and equipment.

He was born in Cincinnati, Ohio, October 18, 1864, and was graduated from the Sheffield Scientific School of Yale with the degree Ph.B. in 1886 and M.E. in 1888. For a short time Mr. Townley worked on the rebuilding of the central lighting station of the Brush Electric Company of Cincinnati. During most of the period from 1887 to the time of his retirement in 1931, he was connected with the Westinghouse interests in various positions. He was erecting engineer in office charge of the design of electric lighting distribution systems (1887), commercial executive (1888–95), manager for the Boston branch (1895–97; 1898–1900) and also associated with the Pittsburgh group of engineers in installation and equipment work throughout the New England states. During this period he was connected with the electrical equipment of the South Terminal of Boston and of the elevated railway system, and the installation of the polyphase transmission system and city lighting system of the Hartford Electric Light Company. He was general agent for the Westinghouse interests in New York (1901–04) in charge of large transportation interests in and about the city; he was concerned with the equipment of the Brooklyn Rapid Transit, Interborough Rapid Transit, and New York City railway systems.

From 1904 to 1911 he was associated with the New York, New Haven, and Hartford Railroad, in various executive capacities and as technical adviser. One of the important projects upon which he worked in both capacities was the electrification of the railroad's lines out of New York City. About this time the company began acquiring utility companies and Mr. Townley was appointed first vice-president of the holding company to manage their utilities as a side issue. The "side issue" reached such magnitude that after completing electrification plans and drawing specifications, Mr. Townley asked to be relieved of construction duties and became consulting engineer for the railroad in the management of utilities.

He returned to the Westinghouse Company in 1911 as assistant to the president, remaining in that position until 1931 when he retired. He died on November 27, 1933. He was also president of the Lackawanna and Wyoming Valley railroads, vice-president of the International Radio Telegraph Company and an officer and director of many other organizations. He was an active participant in Institute affairs, serving as manager (1905–8) and vice-president (1908–10) and as committeeman at various times

Arthur W. Berresford

(A '94, M '06, F '14, member for life)

President 1920–21

IN THE field of electric motor control, Arthur William Berresford occupies an outstanding place. From observations made in early postgraduate days, Mr. Berresford became convinced that proper control devices would make possible extended use of electric motors and generators, and to the problems of construction and application he bent all his characteristic energy, inventiveness and ability to direct and coördinate the work of others.

He was born in 1872 in Brooklyn, and in 1892 graduated from Brooklyn Polytechnic College with the degree B.S. in electricity; the following year he received the degree M.E. in electricity from Cornell University. His first job was electrician for the Brooklyn City Railroad Co., overhauling motors and assisting in trolley line construction, etc. It was a small beginning, in his opinion, but very probably many of his ideas were forming which materialized later, as the next year, 1894, while employed in sales and installation work for the H. B. Coho Company, he carried on experimental work of a "private nature."

Then he was designer for the Riker Electric Company for about a year, going to the Ward-Leonard Electric Company in 1896 to take charge of the detail design of the apparatus and the testing of all material shipped. This company manufactured rheostats and electric controlling devices. In 1898 he organized his own manufacturing business with 2 associates, purchasing the defunct Iron Clad Rheostat Company and renaming it the Iron Clad Resistance Company. In 1900 he sold the concern to The Cutler-Hammer Manufacturing Co., entering the engineering department and becoming superintendent in 1901. Later he was made secretary and in 1905 general manager and vice-president.

In many problems, the rheostat as such plays merely an incidental part, and the knowledge, application, and devising of means for meeting the problems form by far the more important part, and in this phase of the work Mr. Berresford demonstrated his productiveness and ability as a shop manager and director as well as a designer. He was in charge of and responsible for the entire output of The Cutler-Hammer Co. and directly in touch with and responsible for the detail engineering and designing as well as manufacture of such intricate devices as have made possible hoisting and conveying machinery, electrically operated printing-presses, steel mill motors, elevators, etc.

During the war Mr. Berresford was chairman of the general war service committee of the electrical manufacturing industry. In 1926 he entered the field of electric refrigeration as vice-president of the Nizer Corporation of Detroit, which merged to form the Electric Refrigeration Corporation. Since 1929 he has been managing director of the National Electric Manufacturers' Association. He has given unstintingly of his time to Institute affairs, as manager (1909–12), vice-president (1912–14) and as committeeman. He is a member of other technical societies and the recipient of various medals and awards.

William McClellan

(A '04, M '09, F '12)

President 1921–22

A CASUAL glance over the record of the youth and young manhood of William McClellan would make it appear that he was destined for an academic life; as a matter of fact this academic experience formed an excellent basis for his later career as a prominent engineer and economist in the electric traction and public utilities fields.

He was born in Philadelphia in 1872 and graduated from high school at 17 years of age, taking a postgraduate course in electrical engineering the following year. He was an assistant in engineering for 1 year at Swarthmore college, and then taught mathematics and physics in the high schools of Philadelphia for 7 years. At the same time he studied at the University of Pennsylvania for the B.S. degree, which he received in 1900; in 1903 he received the Ph.D. degree. He was instructor in electricity and magnetism in the department of physics at the university from 1900 to 1905. A number of years later he returned to the university as dean of the Wharton School of Finance and Commerce, and in later years continued his connection with the university as director general of the alumni society and as trustee.

From 1900 to 1904 Doctor McClellan also worked in various capacities for the

Union Traction and Philadelphia Rapid Transit companies, some of his important assignments being the erection of a large car barn and the rebuilding of a large power house, including erection of engines, boilers, generators, motors, lighting switchboards, cables, etc. In 1905 he went to New York to do responsible design work for the Westinghouse Church, Kerr and Company on the lighting and power distribution for the Pennsylvania Railroad terminal. He also had charge of the layout and installation of a high-voltage substation and the car equipment for the Erie Railroad, and was design consultant of the Edison Illuminating plants at Brockton, Mass.

From 1907 to 1915 Doctor McClellan was vice-president of the Campion McClellan Company and was responsible for all the mechanical and electrical engineering, design, and construction handled. He drew up numerous reports on power plants and water power developments and took charge of the complete mechanical and electrical equipment and installations for various manufacturing plants. From 1915 to 1920 he was a member of the firm, Paine, McClellan and Campion. Between 1919 and 1921 he was vice-president of the Cleveland Electrical Illuminating Company. In 1922 he became a member of the firm of McClellan and Junkersfeld, remaining in this firm until, in 1929 he was elected vice-president of Stone and Webster Engineering Corporation. At present he is president of William McClellan and Company, Ltd., and of the Potomac Electric Power Company of Washington, D. C.

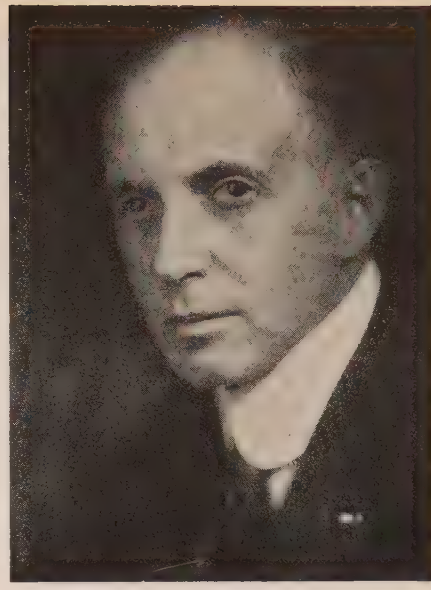
He was consulting engineer for the Public Service Commission of the 2nd district, New York State, from 1911–13 and a member of the President's commission on Muscle Shoals in 1925. During the war he was director of the intercollegiate intelligence bureau in Washington. He has served the Institute over a long period of years as officer and committeeman.

Frank B. Jewett

(A'03, M'10, F'12)

President 1922–23

Edison Medalist 1928



THE outstanding leader in the field of telephone research during the past 30 years is Dr. Frank Baldwin Jewett. Throughout this period he has been in active charge of the research work of the American Telephone and Telegraph Company and its affiliated organizations.

Doctor Jewett was born at Pasadena, Calif., September 5, 1879. In 1898 he graduated from Throop Polytechnic Institute (now the California Institute of Technology) at Pasadena, with the degree of B.A. In 1902 he received the degree of Ph.D. from the University of Chicago. Doctor Jewett then went to the Massachusetts Institute of Technology, Cambridge, where he continued study and was instructor in physics and electrical engineering.

In 1904, Doctor Jewett entered the employ of the American Telephone and Telegraph Company and was shortly thereafter given charge of its engineering research work. From 1908 to 1912, Doctor Jewett was transmission and protection engineer, responsible for the development of much equipment.

In 1912 he became assistant chief engineer of the Western Electric Company, and in 1916 was appointed chief engineer, having charge of the research laboratories of that company; 6 years later he became vice-president. During Doctor Jewett's association with this company, many of the most important advances in the field of communications were made.

In 1925 Doctor Jewett became vice-president of the American Telephone and Telegraph Company, in direct charge of the department of development and research (now combined with the Bell Telephone Laboratories, Inc.) and at the same time was elected president and a member of the board of directors of the Bell Telephone Laboratories, Inc., conducting the laboratory and research work formerly done by the engineering department of the Western Electric Company. He now holds these positions.

In 1917 Doctor Jewett was commissioned major in the Signal Corps, U.S. Reserves, and was later that year promoted to lieutenant-colonel in the Signal Corps of the regular Army. For his service during the war, he received the Distinguished Service Medal.

During 1915–18 Doctor Jewett was a manager of the Institute, a vice-president 1918–19, and president 1922–23. He has served on some 15 of the Institute's committees, and as its representative on 8 other bodies. He has presented many papers and articles before the Institute and other organizations. He has been active in The Engineering Foundation and the National Research Council.

Doctor Jewett is a term member of the Massachusetts Institute of Technology Corporation, and a member of the committee on Carnegie Institute of Technology. He has received several honorary degrees. The Fourth Order of the Rising Sun has been bestowed upon him by the Japanese Government.

Harris J. Ryan

(A'87, M'95, F'23, member for life

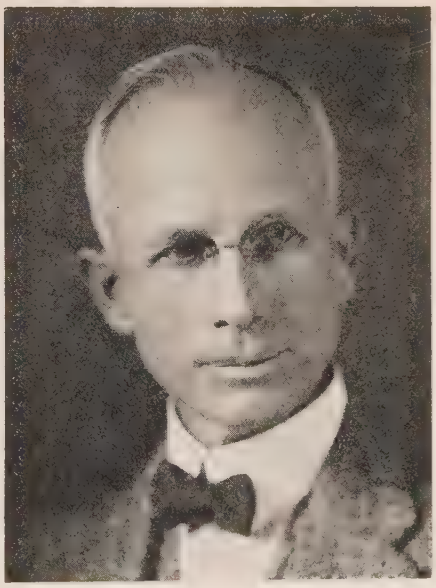
President 1923–24

Edison Medalist 1925

IN 1889, Dr. Harris Joseph Ryan presented before the Institute a paper on transformers, which was immediately recognized as a remarkable one, reaching into the future and exploring the unknown field of high-voltage phenomena. It is the continued exploration of high-voltage phenomena over a period of some 40 years that distinguishes the work of Doctor Ryan.

He was born at Powells Valley, Pa., January 8, 1866. When an electrical engineering course was first inaugurated at Cornell University in 1883, he entered, graduating in 1887 with the degree of M.E. in E.E. For the next 2 years he was associated with J. G. White & D. C. Jackson in general engineering practice at Lincoln, Neb., under the firm name of the Western Engineering Company. In 1889 he returned to Cornell to take charge of the electrical machinery laboratory, and since that time has been concerned principally with scientific research, although he has always been interested primarily in practical applications.

He then started the investigation of high voltages in the laboratory at Cornell, constructing under his supervision much of the equipment necessary. In 1890 he was



chosen assistant professor in electrical engineering, and in 1895, when only 29 years of age, he was appointed professor in full charge of electrical engineering. For a number of years following 1900, he conducted important experiments on the cathode ray oscillograph.

In 1905 Doctor Ryan became head of the electrical engineering department at Stanford University, Calif. Doctor Ryan held this position continuously until 1931, when he retired from active teaching and executive duties. He is now professor emeritus of electrical engineering at Stanford, and honorary director of the Ryan research laboratory.

In the high-voltage laboratory built for him by Stanford University in 1913, much research was carried on which contributed to the present-day success of high-voltage transmission. The Harris J. Ryan high-tension laboratory at Stanford University built in 1926, stands as a fitting monument to the untiring energy and ability of the man whose name it bears.

Doctor Ryan has served the Institute on 11 of its committees, and has been its representative on other bodies. He was manager 1893–96, vice-president 1896–98, as well as president. He also has given his time to several other technical societies.

Doctor Ryan was director of the supersonics laboratory of the National Research Council, Pasadena, Calif., 1918–19. During 1909–23 he served as consulting engineer for the Los Angeles Aqueduct Power Bureau.

In 1925 the degree of LL.D. was conferred upon him by the University of California. He was judge, board of awards, at the World's Fair, Chicago, 1893; U.S. delegate to the International Electrical Congress, St. Louis, 1904; and member of the jury, Panama Pacific International Exposition, San Francisco, 1915

Farley Osgood

(A'05, M'11, F'12)

President 1924–25

THE professional activities of Farley Osgood may be divided into 2 parts, the first of which, 14 years in length, was concerned with the telephone industry, and the second, 25 years in length, was concerned with the electric light and power industry.

Doctor Osgood was born at Chelsea, Mass., in 1874. In 1897, he graduated from a 6-year course at Massachusetts Institute of Technology, part of the time between 1894 and 1897 being spent in the engineering department of the American Bell Telephone Company at Boston.

Between 1897 and 1898, he was traveling engineer for the new England Telephone and Telegraph Company, covering their territory in Massachusetts, Maine, and New Hampshire, making inspections and installations. In 1898, he went to New Jersey with the New York and New Jersey Telephone Company, acting as chief clerk in the operating department, as special plant engineer, as confidential man to the vice-president, and as division manager, until 1904. In the latter year he became chief engineer and general manager of the new Milford (Conn.) Power Company. Here he had charge of the construction

work for the company, and organized its operating forces.

The second phase of Doctor Osgood's career began in 1908, when he joined the organization of the Public Service Electric Corporation of New Jersey (now Public Service Electric and Gas Company) as general superintendent. In 1917, he became vice-president and general manager of this company, remaining in this position until 1924, when he retired to undertake private practice in New York as a consulting engineer. Doctor Osgood maintained this latter activity until his death October 6, 1933.

Doctor Osgood has served the Institute in many capacities, having been manager 1911–14, vice-president 1914–16, as well as president. He was chairman of the New York Section 1921–22, and has been a member of the following committees: Edison Medal, executive, finance, safety codes, standards, coördination of Institute activities, education, meetings and papers (now technical program), and Institute policy. He had also been the Institute's representative on many bodies, including the electrical committee of the National Fire Protection Association, the national joint committee on overhead and underground line construction, joint power factor committee, Charles A. Coffin fellowship and research fund committee, American Engineering Council, John Fritz Medal board of award, and the U.S. national committee of the International Electrotechnical Commission. He was a member of the New York Electrical Society and the former National Electric Light Association.

In 1925 he received the honorary degree of doctor of engineering from Rensselaer Polytechnic Institute.

M. I. Pupin

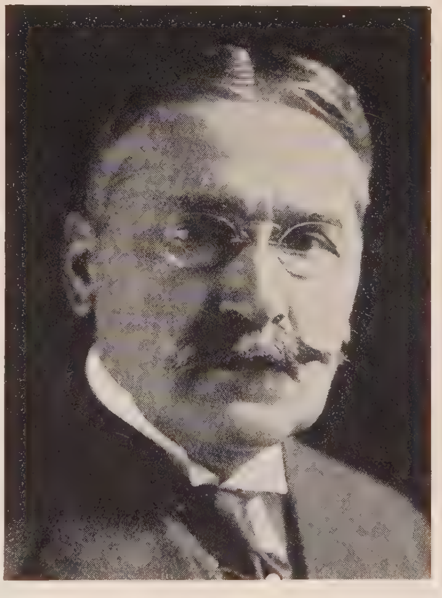
(A'90, F'15, member for life)

President 1925–26
Honorary Member 1928
Edison Medalist 1920
John Fritz Medalist 1932

THE career of Michael Idvorsky Pupin is one of the most unusual in the history of science, and it is indeed fortunate that because of his unusual ability as a writer, the story of this career has become known to thousands through his autobiography, "From Immigrant to Inventor."

Doctor Pupin was born at Idvor, Banat, Hungary, October 4, 1858. Displaying unusual talent at an early age, he was sent to Prague, Czecho-Slovakia, to prepare for higher education, but being attracted by America, ran away from Prague and came to New York in 1874. After having struggled to save sufficient funds, he entered Columbia College, graduating in 1883 with the degree of B.A. He afterward studied physics and mathematics at the University of Cambridge, England, and the University of Berlin, Germany, obtaining from the latter his Ph.D. in 1889.

Returning to America in the latter year, he became instructor of mathematical physics at Columbia University. In 1892, he became adjunct professor of mechanics, and in 1901 was appointed professor of electromechanics. He was appointed director of the Phoenix Research Laboratory of Columbia University in 1903, and retained



this position as well as his professorship until 1929, when he retired from active service with the title of professor emeritus in active residence. Doctor Pupin now holds this latter position.

Doctor Pupin is widely known for his important inventions; his significant contributions to knowledge in a-c theory, the passage of electricity through gases, long distance communication, and many other scientific subjects; and his many publications.

Many of Doctor Pupin's inventions have proved to be commercially successful. Following several years' study, a patent for electrical tuning circuits was granted him, and sold to the Marconi Company in 1902. He was the first to produce an X-ray photograph in this country as a guide to surgical operations, and at that time, in 1896, he also invented a method of rapid X-ray photography. He also made the important discovery of secondary X-ray radiation.

One of his most outstanding contributions was the mathematical solution of electrical transmission over telephone wires with induction coils periodically recurring at specific points; this led to the construction of the so-called loaded telephone conductor now used for long-distance telephone communication. He made fundamental contributions in the rectification of waves.

His ability as a teacher is widely recognized, and many men who later became prominent were among his pupils.

In 1892–95, Doctor Pupin was a manager of the Institute, and a vice-president 1895–97, and 1901–03, and later president. He has served on many of its committees. He is a past-president of the Institute of Radio Engineers, past-chairman of The Engineering Foundation, and a member of many other societies. He has received the medal of honor of the Institute of Radio Engineers, 1924; Cresson Medal of the Franklin Institute, 1902; Prix Herbert, French Academy, 1916; Social Science Medal, 1920; Washington Award, 1928; as well as the John Fritz medal 1932, and the Institute's Edison medal, 1920. He has received some 18 honorary degrees.

C. C. Chesney

(A'94, M'99, F'13, member for life)

President 1926–27

Edison Medalist 1921

CUMMINGS C. Chesney is well known as a pioneer in designing a-c generators for high voltages and many other developments in a-c machinery and high power transmission. He has built up an enviable record as a designer, operating engineer and organizer, first receiving wide recognition as one of the developers of the S. K. C. (Stanley, Kelly, Chesney) apparatus. In 1921 he was awarded the Edison Medal for his early contributions to the development of a-c transmission.

He was born in Selingsgrove, Pa., October 28, 1863. He was graduated from Pennsylvania State College in 1885, and for 3 years taught mathematics and chemistry at the Doylestown (Pa.) Seminary. In 1888 he joined William Stanley's laboratory force at Great Barrington, Mass., working on experimental chemistry and electrodynamics, and the following year entered the services of the United States Electric Lighting Company in Newark.

In 1890 he moved to Pittsfield, Mass., and became a member of the Stanley Laboratory Company; in 1893 when the Stanley Electric Manufacturing Company was organized, he assumed the formal title of chief supervising and designing engineer and the position of first vice-president. In these capacities he was largely responsible for the design, manufacture, and installation of switchboard instruments, high-voltage arc breaking devices, frequency indicators, indicating wattmeters, lightning protection for high- and low-voltage currents, condensers, belt-driven alternators, the first revolving field type of alternator, etc. Shortly after Mr. Chesney and his colleagues developed the well-known S. K. C. system, the first polyphase transmission plant equipped with the system was installed and put into successful operation, in 1893, at Housatonic and Great Barrington, Mass. In 1895 a 12,000-volt plant was installed for service from Lowell to Grand Rapids, Mich. Many other installations followed. Two-phase a-c induction motors, electrostatic condensers at 500 volts and transformers of 100-light capacity were developed. In developing the transformer all spaces in the coils were filled with gilsonite to provide better heat dissipation and insulation. This and the development of cloth treated with oxidized linseed oil occurred as early as 1892.

In 1906 the General Electric Company acquired the Stanley company and Mr. Chesney became Pittsfield works manager and chief engineer, holding this position until 1927. Under his supervision particular progress was made in the development of apparatus for commercial service up to 220,000 volts, and successful tests of 1,000,000 volts for transmission purposes were completed. He is now an honorary vice-president of the General Electric Company.

He has taken an active interest in the affairs of the Institute, serving as manager (1905–08), as vice-president (1908–10) and as committeeman over a long period of years.

Bancroft Gherardi

(A'95, M'04, F'12, member for life)

President 1927–28

Edison Medalist 1932

SINCE the early days of the telephone Bancroft Gherardi has been an outstanding figure. His initiative and skill in the development of engineering and operating organizations and in the development of the art generally have contributed enormously to the growth and success of present-day communication.

Mr. Gherardi was born April 6, 1873, in San Francisco, Calif., and received his education at the Polytechnic Institute of Brooklyn, N. Y., taking the degree B.S. in 1891. In 1893 he received the M.E. degree from Cornell, and in 1894 the master's degree in mechanical engineering. The following year he entered the employ of the New York Telephone Company (then the Metropolitan Telephone and Telegraph Company) where he worked under John J. Carty for 4 years, quickly winning promotion because of his work in improving the cable practice of the company. He was engaged on various problems, planning the scientific arrangement of control stations; he had charge of the planning and supervising of the underground systems and conductor arrangements installed for the city of New Rochelle, N. Y. He also made a study of the efficiency of telephone transmission on underground cables of various types and aerial circuits of various sizes of wire.

In December 1899 Mr. Gherardi became engineer of the traffic department of the company and was responsible for recommendations for new switchboards and additions to switchboards required. In 1901 he became chief engineer of the New York and New Jersey Telephone Company, in responsible charge of the planning and construction of all central office buildings. He made a study of the conditions of telephone development in the New Jersey territory, which involved laying comprehensive underground and aerial lines, based upon the estimated development of the future. He gave special attention to the commercial application of the Pupin loading coils to the underground cable system.

He was assistant chief engineer of the New York Telephone Company, 1906–07. He became engineer of plant of the American Telephone and Telegraph Company, 1907–18, acting chief engineer and chief engineer, 1918–20, and since 1920 he has been vice-president and chief engineer. He is a director of the Michigan Bell Telephone, Cuban American Telephone and Telegraph Companies, the 195 Broadway Corporation, and the Bell Telephone Laboratories, Inc.

Mr. Gherardi has been an active participant in Institute affairs, having served as manager, 1905–08 and 1914–17, and as vice-president, 1908–10. At various times he has been a member of Institute committees, including executive, finance, and research. He is now serving on the committee on Institute policy. He has represented the Institute on the board of trustees of the United Engineering Trustees, Inc., the national committee of the International Electrochemical Commission, the National Research Council and on other bodies. He is a member of several important technical societies in the United States

R. F. Schuchardt

(A'03, M'09, F'12)

President 1928–29

RUDOLPH Frederick Schuchardt was one of the outstanding leaders in central station engineering, and a man who served the Institute enthusiastically and effectively in many of its activities. In addition to his splendid qualifications as an electrical engineer, he maintained adherence to principles of the highest type, and had a keen interest in the development of individual engineers.

Mr. Schuchardt was born in Milwaukee, Wis., December 14, 1875, and in 1897 graduated from the electrical engineering course of the University of Wisconsin. Following graduation he spent a short period with the Janesville (Wis.) Electric Light and Power Company, later in that year joining the staff of Meysenberg and Badt, Chicago, as engineering salesman. In July 1898, he entered the employ of the Chicago Edison Company (later the Commonwealth Electric Company and Commonwealth Edison Company) remaining in this organization until the time of his death, October 25, 1932.

Starting in this company, first as a substation operator for a few weeks and then in charge of the company's exhibit at the Trans-Mississippi Exposition, Omaha, Nebraska, he spent one year in the statistical department of the company. During the period 1899–1906 he was in the testing department, going through all phases from assisting to acting head. In 1906 he became engineer of electrical construction, having charge of this work for all stations and substations. In 1909 he was appointed electrical engineer of the company, subsequently having the title of chief electrical engineer. From 1909 until his death in 1932 he was intimately connected with the development of the company.

Mr. Schuchardt made many contributions to electrical literature since the presentation before the Institute in 1897 of his first paper "Electricity Meters of Today" which attracted considerable attention. He has long been active in the Institute. He served on many committees including the education, power generation, power transmission and distribution, protective devices, standards, Technical Program, executive, electrical machinery, law, Edison Medal, and public policy committees, as well as on the committee on code of principles of professional conduct. He has also been the Institute's representative on 5 other bodies. In addition to the presidency, Mr. Schuchardt served as vice-president of the Institute 1922–24.

Mr. Schuchardt also was chairman of the Chicago section of the Illuminating Engineering Society, chairman of the technical national section of the former National Electric Light Association, and member of the Western Society of Engineers (chairman electrical section 1913), the Society for the Promotion of Engineering Education, and the Institution of Electrical Engineers, of Great Britain. He has been chairman of the public affairs committee of the American Engineering Council, and in 1929 was a delegate to the World's Engineering Conference in Japan. He also has been active in civic affairs.

In 1907, Mr. Schuchardt was awarded the Chanute Medal of the Western Society of Engineers.

Harold B. Smith

A'91, M'01, F'13, member for life)

President 1929–30

THE career of Harold Babbitt Smith was fundamentally that of an educator, supplemented by engineering research in the field of high voltage, and with consulting engineering practice. He was head of the department of electrical engineering at Worcester Polytechnic Institute throughout practically its entire existence up to the time he retired in June 1931. He also contributed freely of his time and support to the technical societies.

Professor Smith was born at Barre, Mass., May 23, 1869. In 1891 he graduated from Cornell University with the degree of M.E. in electrical engineering, remaining there as a graduate student several months thereafter.

In January 1892 he was appointed professor of electrical engineering in charge of the department at the University of Arkansas. Resigning from this position in December of that year, he became head designer and electrical engineer for the Elektron Manufacturing Company, Springfield, Mass. During the period 1893–96 he was director of the department of electrical engineering at Purdue University. It was in 1896 that he became professor of electrical engineering and director of the department at Worcester Polytechnic Institute, which

position he held until his retirement in 1931. His death occurred February 9, 1932, at Worcester, Mass.

Profess r Smith retained his connection with the Elektron Manufacturing Company as consulting engineer until 1902, and did consulting work for several other organizations at various times. From 1905 until 1931, he had served as a consulting engineer for the Westinghouse Electric and Manufacturing Company.

Professor Smith was one of the pioneers in the development of high-voltage power transmission systems and equipment, and carried on many researches involving dielectric phenomena and stress distribution. He held numerous patents on his inventions, and had contributed many papers to the various engineering societies of which he was a member.

He was chairman of the international group, jury of awards in electrical engineering at the St. Louis Exposition, 1904. During 1917–19, he was an associate member of the Naval Consulting Board and consultant of the special board of the Navy on anti-submarine work.

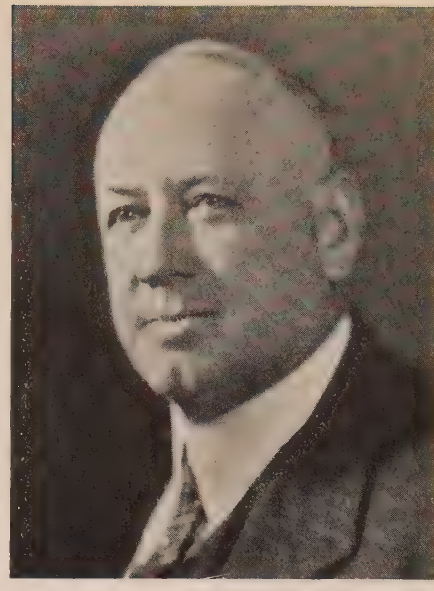
Professor Smith had served the Institute as manager 1920–24, vice-president 1924–26, and as president. He had served on 13 of the Institute's committees, being particularly interested in the Sections and Student Branches committees, and the educational committee. He had been the Institute's representative on 4 other groups. Professor Smith was a member of the American Society of Mechanical Engineers, Institution of Electrical Engineers (Great Britain), Society for the Promotion of Engineering Education, and the American Association for the Advancement of Science.

Two honorary degrees were conferred upon him in 1929; these were doctor of engineering from Purdue University and from Worcester Polytechnic Institute.

W. S. Lee

(A'04, M'05, F'13)

President 1930–31



THE development of the electric power industry in the southeastern part of the United States was the constant endeavor throughout the engineering and business career of William States Lee. Mr. Lee was one of the outstanding figures in the industry at the time of his recent death, March 24, 1934.

Mr. Lee was born in Lancaster, S. C., January 28, 1872. He received the degree of C.E. from The Citadel, the Military College of South Carolina, in 1894. He received the honorary degree of doctor of laws from this institution in 1932, and that of doctor of science from Davidson College, N. C., in 1929.

Following graduation, he was obliged to teach 2 years, in return for the free scholarship to the Citadel, which he had won in a competitive examination.

In 1897 he was appointed resident engineer at the Anderson (S. C.) Light and Power Company. In 1898 he became resident engineer of the Columbus (Ga.) Power Company, becoming chief engineer of this company in 1902. He next went with the Catawba Power Company, Charlotte, N. C., being appointed chief engineer in March 1903, and vice-president and chief engineer in October of that year. This company was a subsidiary of the Southern Power Company, and in 1905 he became chief engineer of the latter company. He later received the appointment of vice-president and chief engineer, which position he held for about 15 years. At the time of his death in March of the present year, Mr. Lee was vice-president and chief engineer of the Duke Power Company, Charlotte, N. C., and president of W. S. Lee Engineering Corporation of New York and Charlotte.

Mr. Lee held a number of other offices, being president and chief engineer of the Piedmont and Northern Railway Company, vice-president and chief engineer and director of the Wateree Power Company, Western Carolina Power Company, and Catawba Power Company.

Mr. Lee was long associated with the late James B. Duke, and together they were active in the construction of many power systems and the development of hydroelectric resources in the south. Probably Mr. Lee's most notable achievement was the designing and building of the Duke Power Company system, consisting of some 32 hydroelectric stations and 7 steam electric stations, with a generating capacity of more than 1,000,000 kva. He also designed and supervised the building of the Duke-Price Power Company's Isle Maligne station on the Saguenay River, Quebec, Canada. He was consulting engineer for the Alcoa Power Company, and designed the Beauharnois Plant which is now being constructed on the St. Lawrence River, near Montreal; when completed it will probably be the largest hydroelectric plant in the world.

Mr. Lee has given freely of his time to the Institute, having been a manager 1911–14, and a director 1929–30, in addition to having been president. He has served on 8 of the Institute committees and been its representative on several other bodies. He was particularly active in American Engineering Council, having been its president for the 2 years 1932–33. He was a member of several other societies.

C. E. Skinner

(A'99, M'03, F'12)

President 1931–32

AN UNUSUAL record of service has been made by Charles Edward Skinner, who not only spent over 42 years participating in the engineering development of one industrial concern, but who has worked for the advancement of the entire profession for a period of many years. His record with the Institute is striking, in that he has served on 17 of its committees, having been chairman of several of these, and has been its representative on 10 other bodies. As an officer, in addition to having been president, he was manager 1915–19, and vice-president 1919–20.

Doctor Skinner was born near Redfield, Ohio, May 30, 1865. He studied at Ohio University and Ohio State University, graduating from the latter in 1890 with the degree of M.E. On August 16, 1890, he joined the organization of the Westinghouse Electric and Manufacturing Company and remained with that company continuously until his retirement from the company January 1, 1933. Living at Wilkinsburg, Pa., he has continued his support of the Institute's affairs, and has taken part in many other endeavors.

His first position with the Westinghouse Company was as a machinist in charge of the manufacture of railway controllers. In 1891 he was put in charge of all insulation design as well as testing, and in 1892, in addition, took up magnetic testing and the development of magnetic materials. He remained in charge of this latter work for many years.

In 1906 Doctor Skinner organized the research division of the engineering department of the Company, and was responsible for the organization and equipment of the chemical, physical, and process laboratories, as well as the high voltage test laboratories. Through his efforts a laboratory for more fundamental research was determined upon in 1915, and he had charge of the building, equipping, and organization of the personnel of this laboratory. In 1920 he was made manager of the research department, having direct charge for the next 2 years. In 1922 he was made assistant director of engineering, holding this position until his retirement at the beginning of 1933.

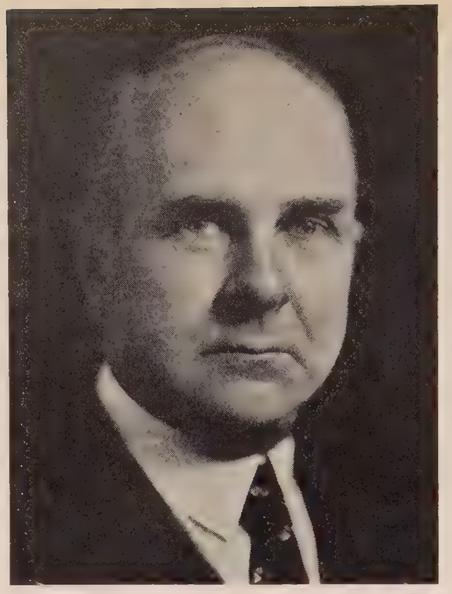
Doctor Skinner has for many years been particularly active in the field of standardization and has been chairman of American and international standards associations. He has many times been a delegate to international congresses and commissions at meetings in various cities in Europe, and in Japan, and was chairman of the American delegation at 2 of the meetings of the International Electrotechnical Commission.

Doctor Skinner is a member of a very large number of technical societies, and has published many writings on insulation, testing, magnetics, research, standardization, and education. In 1927 he received the honorary degree of doctor of science from Ohio University. In 1931 Doctor Skinner was awarded the Lamme Medal of Ohio State University, one of the 3 medals established by the late Benjamin G. Lamme

Harry P. Charlesworth

(Member 1922, Fellow 1928)

President 1932–33



HARRY Prescott Charlesworth ranks among the outstanding engineers in the field of telephone plant engineering having handled with repeated success large responsibilities in the Bell system, which required an executive ability of the highest order and a thorough understanding of engineering principles and practice.

He was born in Haverhill, Mass., April 7, 1882, and after attending the public school and Wheeler's Academy there, he entered Phillips-Exeter Academy in Exeter, N. H., where he prepared for college. He received the B.S. degree from the Massachusetts Institute of Technology in 1905 and immediately joined the staff of the American Telephone and Telegraph Company, then located in Boston.

For the first 2 years he worked in the circuit development division of the engineering department. Then in 1907 he was transferred to the toll traffic division.

During the period 1907 to 1919 he was assigned to special problem work. Among the more important of these assignments were the development of alternating high-voltage telegraph systems and the development of systems for use with small gauge long cable circuits. He also acted as advisory engineer to the Chesapeake and Potomac Company in important matters having to do with the Government telephone requirements in Washington, from 1917 to 1919 during the course of the War.

In 1919 he became equipment and transmission engineer of the engineering department of the American Telephone and Telegraph Company, and a year later he was appointed plant engineer, taking responsible charge of the design of the telephone properties and having general supervision over the entire plant engineering work of the Bell system. He has acted as consulting engineer for the chief engineers and executive managers of the associated Bell companies throughout the country.

In 1928 he was elected vice-president of the Bell Telephone Laboratories, Inc., where he directed development, research and related activities pertaining to the art of telephonic communication. In 1933 he resigned to accept his present position as assistant chief engineer of the American Telephone and Telegraph Company in New York.

Mr. Charlesworth has been especially generous in giving his time to Institute activities. He was a manager (1924–27), chairman of the meetings and papers (now technical program) committee (1927–29) and chairman of the New York Section (1929). In 1930 he became vice-president (representing district No. 3) and a member of the board of directors. He has participated as member and chairman of many committees. At present he is serving on the executive, Institute policy, and Edison medal committees, the special committee on model registration law, and represents the Institute on the John Fritz medal award committee. He is a member of the board of United Engineering Trustees, Inc., and a member of National Research Council, division of engineering and industrial research. He is a member of the corporation of the Polytechnic Institute of Brooklyn.

John B. Whitehead

(A'00, M'08, F'12, Life Member)

President 1933–34

JOHN Boswell Whitehead, now serving the Institute as president for the 1933–34 term, has long been prominent in the academic field for his work as a teacher and for his outstanding researches on the problems of dielectrics and corona phenomena. He is also well known as a consulting engineer in these latter fields.

He was born at Norfolk, Va., August 18, 1872, and studied at Johns Hopkins University, receiving the degrees E.E. (1893), B.A. (1898) and Ph.D. (1902). His first position was with the Westinghouse Electric and Manufacturing Company, working in the shop, laboratory and engineering department for one year and designing for 2 years. In 1897 he was plant engineer for the Niagara Falls Power Company and in charge of the plant of the Pittsburgh Reduction Company. From 1898 to 1904 he was instructor in electrical engineering at Johns Hopkins, becoming associate professor of applied electricity in 1905. In 1919 he became professor, and since 1919 has been dean of the school of engineering.

In addition to teaching Doctor Whitehead has carried on an extensive consulting practice. From 1899 to 1900 he worked for the Rowland Multiplex Telegraph System. In 1902 he undertook research work with the Bureau of Standards, and from 1902 to 1905 he was research assistant at the Carnegie Institution. From 1900 to 1908 he had charge of the power plant of the university. Over a period of 12 years, from 1900 to 1912, he was consulting engineer for the Maryland Railways Company. A noteworthy piece of work he did for the company was the design and supervision of the installation of the single-phase equipment for the Baltimore-Annapolis Short Line (1906–08). In later years his work on high-voltage insulation has been outstanding. He has been consultant and director for various projects in this field supported by the former National Electric Light Association, Utilities Research Commission of Illinois and the Engineering Foundation.

Doctor Whitehead has been active in Institute affairs for many years. He founded the Baltimore section and was its chairman for 19 years. He has served as a member of the board of directors (1924–28), chairman of the electrophysics committee (1912–16), and research committee (1922–27). From its inception he has been identified with the work of the latter. In 1927 he organized the committee on electrical insulation of the National Research Council's division of engineering and industrial research, serving continuously as chairman. He also is serving on the executive and Edison medal committees of the Institute and is the Institute's representative on American Engineering Council, the John Fritz medal award committee, and the Charles A. Coffin fellowship and research fund committee.

He served as major in the engineering division of the Reserve Officers Corps during the War. In 1926 he was exchange professor in engineering and applied science to France. Honors awarded him include the Edward Longstreth Medal and the Elliott Cresson Gold Medal of the Franklin Institute, the Montefiore award, and the Medaille d'Honneur of the University of Nancy, France, 1927.

Honorary Members and Medalists

Other Than Those Who Served Terms as Presidents

Biographical sketches of Honorary Members of the Institute and the recipients of its medals are given on the following pages, excepting only those Honorary Members and medalists who also served terms as presidents of the Institute. Biographical sketches of this latter group have been given on the preceding 23 pages.

Sir William Preece

Honorary Member 1884

THE first regular meetings of the Institute following organization meetings were held on October 7 and 8, 1884. A few days later, on October 21, Sir William Henry Preece, pioneer in the electrical industry in Great Britain, was elected as the first Honorary Member of the Institute. He had much to do with the laying of the foundations of applied electricity, in telegraph engineering in particular. He was born in England on February 15, 1834. After leaving King's College, London, where he was educated, he spent a short time in the telegraph engineering offices of Edwin and Latimer Clarke, and in 1853 joined the Electric and International Telegraph Company. After a number of years' experience in the telegraph companies, he became a divisional engineer under the British post office, when, in 1870, the various telegraph companies were transferred to the State. He subsequently became electrician and later engineer-in-chief to the post office, retiring in 1899, when he took up a consulting practice. Sir William Preece's official duties did not deter him from taking a very active part in the affairs of the engineering profession. He was a member of many scientific societies, and contributed largely to their proceedings. For the Institution of Civil Engineers and for the Institution of Electrical Engineers (both of Great Britain) he served as president and he was at one time chairman of the council of the Royal Society of Arts. He was a Fellow of the Royal Society.

Mr. Preece's name is connected with many improvements and inventions in telegraph work. At the age of 21 he patented a system of duplex telegraphy; he subsequently took out a number of patents on railway signaling apparatus, although most of his inventions concern telegraph apparatus directly. He also invented a new telephone in 1878, and was proud in later years of having, in 1892, originated a system of signaling across space by induction telegraph with the aid of 2 parallel telegraph lines. Upon the introduction of wireless telegraphy, Mr. Preece became an active supporter of this new method of communication, and maintained an active interest in the progress of science until he died, November 6, 1913.

Moses G. Farmer

(Associate 1884)

Honorary Member 1890

THE THIRD individual to be awarded honorary membership in the Institute was Prof. Moses Gerrish Farmer, a charter member, whose election on October 21, 1890, followed that of Dr. Norvin Green (see p. 788 this issue).

Professor Farmer was born February 9, 1820, at Boscawen, N. H. He studied at Dartmouth College 1840–43. After having charge of a private school, he gave up this work in 1847 to devote his entire time to scientific pursuits. In this year he invented an electromagnetic engine, and in an exhibition at Dover, N. H., on July 26 of that year, transported passengers on a miniature electric railroad. After lecturing on this invention a number of times, he opened a telegraph office at South Framingham, Mass., and there devised an electrical fire alarm system. This was shown by him in Boston in 1849, and afterward perfected in conjunction with Dr. W. F. Channing. The system was first placed in operation in 1852. Professor Farmer subsequently devised many machines and much equipment of importance in the very early days of the electrical industry. In 1852, he devised a system of 2 or more closed circuit repeaters, and in 1853 patented apparatus for simultaneous transmission of 4 messages on one wire. He then became interested in dial telegraphy, duplex and multiple transmission, and the manufacture of rubber insulation. Becoming interested in electric lighting, in 1859 he invented an automatic regulator for controlling current to electric lamps, and illuminated his own house by electricity that year. Among his many other activities, he is reported to have been the first to construct a self-excited magneto-electric machine. Professor Farmer was connected with many scientific associations of the day. He died at Chicago, Ill., May 25, 1893, where he had gone to prepare an exhibition of his early inventions for the Columbian Exposition.

Cyrus W. Field

Honorary Member 1892

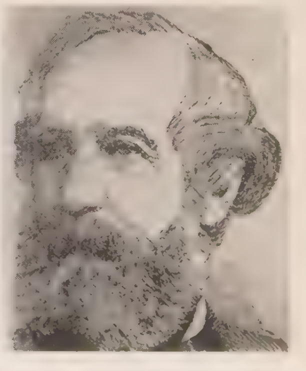
CYRUS West Field, promotor of submarine telegraphy, was elected an Honorary Member of the Institute May 17, 1892. Like many of those connected with the early history of the Institute, his principal activity was in the telegraph industry.

He was born November 30, 1819, in Stockbridge, Mass. At the age of 15 he entered a mercantile house in New York, but when about 20, went into business for himself and soon became prosperous. In 1853 he partially retired and spent several months in travel. Meeting a Canadian engineer, who had attempted to lay a subterranean telegraph line across Newfoundland, Mr. Field's imagination was immediately fired with the idea of laying a submarine cable across the Atlantic ocean. From this time, January 1854, until the transatlantic cable was successfully completed July 27, 1866, Mr. Field worked unceasingly in the accomplishment of this endeavor. He put a large part of his own funds into the enterprise, and succeeded in interesting many others in the venture. The first cable was received from England and was to be laid across the Gulf of St Lawrence, but during a gale the cable was cut in order to save the ship after 40 miles had been laid. Additional financing, which became necessary, was secured in England, and by an appropriation of the U.S. Congress. Starting from the shore of England, 335 miles of cable were laid, when the cable parted on August 11, 1857. In 1858, a cable was started from each shore, and after considerable difficulty, was spliced on July 29. While celebration of this event was going on, the cable parted, and it was not until 1865 that the work of laying the cable was again begun. The now famous steamship "Great Eastern" was used in this endeavor, and after unsuccessful attempts, the laying was completed in 1866. Many honors were bestowed upon Mr. Field in the United States, England, France, and Italy, for his success. Mr. Field subsequently became interested in the development of elevated railways in New York City, and in other submarine cables. His death occurred July 11, 1892.

Mr. Field shared with Professor Farmer the distinction of being the only American elected to honorary membership until the election of Thomas A. Edison in 1928.

SIR WILLIAM PREECE

M. G. FARMER



CYRUS W. FIELD

Lord Kelvin

Honorary Member 1892
John Fritz Medalist 1905

WILLIAM THOMSON, first Lord Kelvin, the noted British scientist, past-president of the Institution of Electrical Engineers, Great Britain, was elected an Honorary Member of the Institute, May 17, 1892. Lord Kelvin was born in Belfast, Ireland, June 25, 1824. He graduated from St. Peter's College, Cambridge, in 1845, where he won notable honors. At the age of 22, he became professor of natural history at the University of Glasgow, and remained with that institution the rest of his life. He was elected a chancellor of the university in 1904. He was knighted in 1866, as one who had done more than any other scientific man to develop submarine telegraphy. In addition to many inventions in telegraphy, he originated the quadrant electrometer, improvements on the compass, and several other inventions. In 1892, he was made a peer by Queen Victoria, and subsequently received a great many honors. Lord Kelvin made many contributions to fundamental theory of electricity. He had a passion for the investigation of natural phenomena, and had acquired a mastery of mathematics that served him as a valuable instrument of research and partly accounted for his remarkable precision of thought. His participation in the activities of scientific and engineering organizations, long after their power to confer distinction upon him had ceased, deserves emulation. His death occurred December 17, 1907.

E. W. von Siemens

Honorary Member 1892

DR. Ernst Werner von Siemens, inventor, promoter of the telegraph and other early electrical apparatus, and a founder of the German firm of Siemens and Halske, was elected to honorary membership in the Institute July 17, 1892. Doctor Siemens was born in Germany in 1816, the eldest of 7 brothers, all of whom achieved distinction in the pursuit of science. His early life was spent in acquiring an education at the Gymnasium of Lubeck, and afterward in the study of military practice and theory. At the age of 28, he was appointed superintendent of artillery workshops and devoted his attention to the application of mechanical, electrical, and chemical science to the defences of his country. About 1848, Doctor Siemens proposed the use of subterranean instead of overhead telegraph lines, and invented a machine for applying seamless gutta-percha to the conductor. Shortly after this he retired from the army, and commenced to devote his whole energy to investigations of theoretical and applied science. His numerous achievements in practical electricity include dial and printing telegraphs, development of the duplex telegraph circuit, apparatus for localizing faults in electric cables, the polarized relay, an electrical range-finder, and the development of the self-excited dynamo, and methods of armature winding. In 1879, he exhibited an electric railway in Berlin. One of the earliest forms of self-regulating arc lamps also is attributed to this prolific inventor. He received from the University of Berlin, in 1860, the honorary degree of Ph.D. Among other honors, a patent of nobility was conferred upon him by the Emperor Frederick III, and he had received the highest scientific order of his country, the Prussian order, "for merit." Doctor Siemens died December 6, 1892.

André Blondel

(Associate 1905)

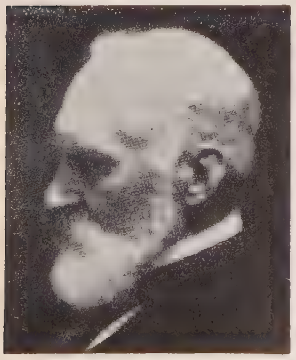
Honorary Member 1912

ANDRÉ E. Blondel, who is now professor of applied electricity at l'Ecole Nationale des Ponts et Chaussées, Paris, France, was elected an Honorary Member of the Institute January 12, 1912. He was born at Chaumont, France, in 1863. Graduating from the universities of Paris and Dijon in 1889, he was then appointed engineer in the Department of Ponts et Chaussées (civil engineering). From 1890 to 1927 he was engaged in the lighthouse service of that department, successively with the titles of engineer-in-chief and inspector-general. Since 1904 he has held his present position of professor of applied electricity. During his long service, he has been instrumental in introducing many important changes in signaling on the coasts of France, principally by wireless. In 1897 he conducted an exhaustive series of experiments on the electric arc. These led him to study the measurement of electrical quantities and to develop the art of photometry, upon which he has long been a leading authority. His investigations have been extended to the advancement of electrical theory and practice in relation to many types of equipment, including generators, motors, and transmission equipment, and he has to his credit many inventions. His published contributions to the science of electrical engineering have been extensive. He has presided over committees and commissions, national and international, and has received many honors.

C. E. L. Brown

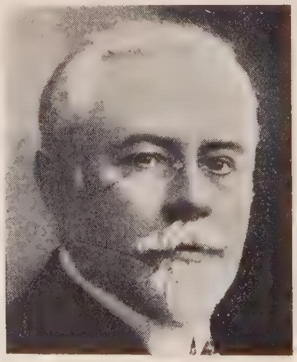
Honorary Member 1912

CHARLES Eugene Lancelot Brown, famous Swiss engineer and organizer of Brown, Boveri and Company, was elected on January 12, 1912, to be an Honorary Member of the Institute. He was born in Switzerland in 1863, the son of an engineer of exceptional ability. After a year's apprenticeship, he organized an electrical department in the locomotive plant at Basle, and in 1874, at the age of 20, he entered the service of the Oerlikon Engineering Works, for which, 2 years later, he became director of the electrical department. In 1885, he conceived a type of armature winding for rotating machines now commonly used. The following year he undertook d-c high-voltage transmission, developing several unusual features of equipment. Turning to a-c machinery, in 1889, he designed some of the first oil-insulated transformers, and produced generators suitable to the new requirements. In 1891 he organized his own concern of Brown, Boveri and Company, at Beden, Switzerland, where he took up the development of the revolving-field type of alternator. The following year the concern undertook the commercial production of induction motors. Among the many developments which Mr. Brown pioneered, the introduction of slow-speed machines was one most frequently connected with his name. He did much original work in the design of switch and control gear, and in the development of the steam turbine. In 1900 he became president of the board of directors of Brown, Boveri and Company, retaining this position until 1911 when he retired. In 1912 a honorary doctor's degree was conferred upon him by the technical college of Karlsruhe. His death occurred May 2, 1924.



LORD KELVIN

E. W. VON SIEMENS



ANDRÉ BLONDEL

C. E. L. BROWN

Emil A. Budde

Honorary Member 1912

DR. Emil Arnold Budde, prominent German scientist and electrical engineer, was elected an Honorary Member of the Institute January 12, 1912. Doctor Budde was born July 28, 1842. He was educated at the gymnasiums of Arnsberg and Dusseldorf and at the University of Bonn, where after graduation he became assistant in mathematics and physics. During the Franco-German war he was a war correspondent for the *Koln Zeitung*, later becoming editor and then foreign correspondent. In 1887 he opened a private laboratory in Berlin and in 1892 was appointed physicist with the Siemens and Halske Company, of which organization he was director from 1893 on, for many years. He contributed largely to German scientific publications. Doctor Budde was official delegate for Germany with Helmholtz at the International Electrical Congress at Chicago in 1893. He was one of the founders of the Verband Deutscher-Electrotechniker of which he served as secretary and later president. He was president of the International Electrotechnical Commission succeeding Dr. Elihu Thomson. Doctor Budde died August 19, 1921.

S. Z. de Ferranti

(Associate 1903, Member 1906)

Honorary Member 1912

SEBASTIAN Ziani de Ferranti was one of the pioneers in the field of electric power distribution in Great Britain, and in recent years had made many contributions in radio development. He was born at Liverpool, England, April 9, 1864, and was educated at St. Augustine's College, Ramsgate, and University College, London. At any early age he displayed unusual ability in machine design, and when between 10 and 12 years old he had produced original drawings demonstrating his extraordinary grasp of detail. Continuing to direct his attention to the development of electrical devices throughout his life, he had to his credit inventions in various lines which are among the most notable contributions to the electrical art. When 22 years of age he began his work of supplying London with electricity from a plant remote from the city, and in 1891 the scheme was perfected and the regular transmission of current at 10,000 volts to the city was initiated. The large Ferranti power plant at Hollinwood was started in 1895. In the construction of this and other early power plants, Mr. Ferranti showed great ingenuity in overcoming the difficulties which were constantly arising. In recent years Doctor Ferranti had been interested chiefly in radio developments and devoted exhaustive study to audio-frequency transformers, which he brought to a high degree of perfection. His contributions to the profession have been marked. In 1910 Doctor Ferranti was elected president of the Institution of Electrical Engineers, of Great Britain, and in 1926 was elected to honorary membership in this institution. On January 12, 1912, Doctor Ferranti was elected an Honorary Member of the A.I.E.E. His death occurred January 13, 1930. He received the honorary degree of Sc.D. from the University of Manchester in 1911; in 1924 he received the Faraday medal of the Institution of Electrical Engineers, and in 1927 he was elected a fellow of the Royal Society.

Antonio Pacinotti

Honorary Member 1912

PROFESSOR Antonio Pacinotti, original inventor of the d-c dynamo with its commutator, and of the ring and toothed types of armature, was born at Pisa, Italy, June 17, 1841; his death occurred in that city on March 24, 1912, only a few weeks after his election on January 12, 1912, as an Honorary Member of the Institute. Under the direction of his father he early began the study of electromagnetism, and by the time he was 17 years of age had the principles of the d-c generator well in mind, constructing in 1860 the celebrated machine which 10 years later was reinvented by Gramme. After 3 years of experimentation with his models, Professor Pacinotti published an illustrated description of his dynamo in the *Nuovo Cimento* in 1864, but this received little attention at the time. The machine described by the young Italian embodied for the first time the ring armature with its symmetrically grouped coils closed upon themselves and connected to the bars of a commutator, the brushes of which delivered practically non-fluctuating current. Early in his work the Italian inventor discovered the reversibility of the dynamo of his creation, having noted that if the machine were supplied with energy from an outside source it would run as a motor. In 1862 he was appointed to the assistant professorship of astronomy at Florence, and, having to renounce carrying out his electrical experiments on the enlarged scale he had planned, then prepared the *Nuovo Cimento* description of his generator already mentioned. In 1864 he received the professorship of applied physics at Bologna and in 1873 was appointed professor of physics at Cagliara. At the Vienna exposition in 1873 he exhibited his dynamo model made in 1860, and for the first time received wide credit. A medal of progress was granted Professor Pacinotti at Vienna, and other medals of honor were given him in 1881 at Paris. At the time of his death he was professor of technological physics at the University of Pisa and senator of the kingdom of Italy.

S. P. Thompson

(Associate 1897)

Honorary Member 1914

SILVANUS Phillips Thompson, noted physicist and electrical engineer of Great Britain, and celebrated as a teacher and writer on electricity and magnetism, was elected an Honorary Member of the Institute March 13, 1914. He was born at York, England, June 19, 1851. Upon graduation from London University in 1869, he took up the study of chemistry and physics at the Royal School of Mines, also studying at foreign universities. In 1875 he received the degree of B.S. from the University of London, and in 1878 that of Sc.D. from the same university. He became professor of experimental physics at Bristol University College in the latter year. Here he began a series of investigations covering a wide range of problems in physics and electricity, becoming an authority on the subject of dynamo-electric machines. In 1885 he became principal and professor of physics at the City and Guilds Technical College at Finsbury, London. At the time of his death June 13, 1916, he was principal and professor of electrical engineering at this college. He was a fellow of the Royal Society, and was a past-president of the Institution of Electrical Engineers, of Great Britain. Doctor Thompson had also made many contributions to the history of science and philosophy.

EMIL A. BUDDE

S. Z. de FERRANTI

ANTONIO PACINOTTI

S. P. THOMPSON

Guglielmo Marconi

Honorary Member 1917
John Fritz Medalist 1923

GUGLIELMO Marconi, Italian inventor, famous for establishing wireless telegraphy on a commercial basis, was elected an Honorary Member of the Institute on August 14, 1917. He was born in Italy on April 25, 1874, and was educated privately. In 1895 the idea became firmly rooted in his mind that a system of telegraphy through space, could be provided by means of electromagnetic waves, the existence of which had already been determined. Marconi was the first to devise practical means by which these waves could provide a new method of communication. In 1896 he went to England, taking out during that year the first patent ever granted on wireless telegraphy. An extensive series of experiments followed, and his first commercial company was organized in 1897. During the next few years, he took out many patents on new devices in wireless telegraphy, and had much to do with the remarkable growth of this industry in many countries of the world. He also was one of the pioneers in the use of short-wave for radio communication. During the World War, Marconi served in both the Italian Army and Navy; and also visited America as a member of the Italian War Commission to the U.S. Government. He was appointed a delegate to the Peace Conference in Paris in 1919. Among the many honors he has received are the Nobel Prize for physics in 1909, the Albert Medal of the Royal Society of Arts, of Great Britain, and the 1932 Kelvin Medal of the Institution of Civil Engineers, of Great Britain. He has been decorated with the Italian order of St. Maurice and St. Lazarus, and with the Grand Cross of the Crown of Italy. In 1915 he was nominated senator of the Kingdom of Italy. In the United States, he has received the Franklin and John Fritz medals and Medal of Honor of the Institute of Radio Engineers. He is president of the Marconi Wireless Telegraph Company, Ltd., at London, England.

Oliver Heaviside

Honorary Member 1918

OLIVER Heaviside, English scientist, who has been recognized as one of the most eminent exponents of electrical science, particularly for his development of the electromagnetic theory, was elected to honorary membership in the Institute on February 14, 1918. Mr. Heaviside was born in England in 1848, and lived there until his death in 1925. His retiring character and desire to avoid society, partly due to almost complete deafness since childhood, has resulted in his name being unknown to the general public, but those who have come in contact with his work regard him as an illustrious successor to Wheatstone, Maxwell, and Kelvin. He lived alone in a cottage at Lower Warberry, Torquay, England, in poverty, a pension of £200 a year having practically been forced upon him. While he wrote papers of great value for the Philosophical Magazine of the Royal Society of London and for the *London Electrician*, for which he received but scant remuneration, these papers were difficult to read and little known. No pictures of him exist and few of his admirers ever met him. His writings, however, had considerable practical value, particularly his mathematical theory of the value of distributed self-induction in long distance telephony, a theory which was later used for practical application and to telephony, establishing a new epoch in this field. The Royal Society, of England, had elected him to fellowship.

Ferdinand Foch

Honorary Member 1921

FERDINAND Foch, Marshal of France from August 9, 1917, until his death, March 20, 1929, was made an Honorary Member of the 4 national societies of civil, mining and metallurgical, mechanical, and electrical engineers, at an impressive ceremony held in the Engineering Societies' Building, New York City, on February 13, 1921. This award was made to "the world's greatest soldier in recognition of his unparalleled service to mankind." In Marshal Foch's brief speech of response he paid tribute to the engineering profession in the following words: "It was due largely to engineering and the engineering industry that the war was brought to a successful conclusion. To the engineering profession also we are indebted for many great lessons which will be vital to mankind in the future. The armies could not have done a great deal without the effort of the engineer. Success was made possible to a great extent by the industry of the people at home but when it became a question of decision, when the decisive moments arrived, the engineer stood out as an essential factor in complete triumph. What would have become of the armies without the technical training, without the professional knowledge which you have exercised for the Allies and which enabled us to lead our armies in the field, to feed them, to protect them, and to facilitate their advance quickly and decisively? It is for these reasons that I am pleased to find you here today, to receive from you so splendid a welcome and to express my gratitude and the gratitude of France, as well as the recognition of my countrymen for the tremendous sacrifices made by you and the men of your calling. I am grateful to you for including me in your ranks as a member of the 4 great engineering societies of the United States."

Thomas A. Edison

(A'84, M '84, member for life)

Honorary Member 1928
John Fritz Medalist 1908

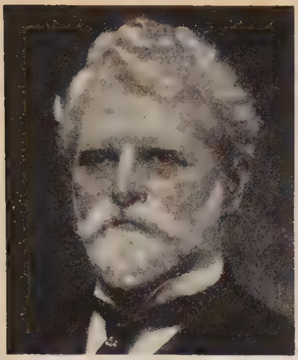
THOMAS Alva Edison, the outstanding inventor in the history of the electrical industry, was born at Milan, Ohio, February 11, 1847. The following minute, adopted by the Institute's board of directors shortly after Mr. Edison's death, indicates briefly the tremendous scope of his activity: "The physical life of Thomas Alva Edison, world benefactor, ended on Sunday, October 18, 1931. The spiritual benefits of his contributions to humanity continue to live. His genius, vision, patience, persistence, industry, and widely diversified talents, which brought to fruition many of his conceptions, have contributed greatly to the comfort, convenience, and happiness of mankind, and his achievements constitute a great incentive and inspiration to those who follow. In particular, his invention of the incandescent electric lamp and his conception, more than 50 years ago, of the combination of a central generating station with a suitable distributing system for electrical energy, firmly establish him as the founder of the electric lighting industry of the world. He was the outstanding world leader in the group of inventors, scientists, and engineers whose achievements in technology have produced great social and economic benefits, including the employment, in useful occupations throughout the civilized world, of tens of thousands of men and women. He was respected and admired by his associates who cherish their memory of his ability, simplicity, and other personal characteristics. Mr. Edison was, in 1884, one of the signers of the call for the organization meeting of the American Institute of Electrical Engineers, and he was elected a vice-president at the first election of officers; later he was elected an Honorary Member. His achievements caused a group of his associates and friends to establish the Edison Medal, which is now awarded annually by this Institute."

GUGLIELMO MARCONI

FERDINAND FOCH

THOMAS A. EDISON

AMBROSE SWASEY



HERBERT HOOVER

CHARLES F. BRUSH

MOTOJI SHIBUSAWA

Ambrose Swasey

Honorary Member 1928
John Fritz Medalist 1924

THE devotion of Ambrose Swasey, famous manufacturer of precision instruments and mechanisms, to the engineering profession, is evidenced by his founding of the Engineering Foundation in 1914. Doctor Swasey has contributed gifts totaling $750,000 to the Foundation, research agency of the 4 national societies of civil, mining and metallurgical, mechanical, and electrical engineers. Doctor Swasey was born at Exeter, N. H., December 19, 1846. During the period 1869–80 he was with the Pratt and Whitney Company, Hartford, Conn., paying special attention to gearing. In 1880, he went into partnership with W. R. Warner (incorporated in 1900 as The Warner and Swasey Company) for the manufacture of machine tools and astronomical instruments. The firm was first established in Chicago, but soon was transferred to Cleveland, where it has since remained. Since the death of Mr. Warner, Doctor Swasey has been chairman of the board. Many remarkable telescopes have been built by this firm, and during the war it solved many important problems. In 1924, the John Fritz Gold Medal was awarded Doctor Swasey; he has also received the Franklin Medal, highest award of the Franklin Institute. In addition to honorary membership in the A.I.E.E., which was awarded him June 27, 1928, he is an honorary member of The American Society of Mechanical Engineers (president 1904), American Society of Civil Engineers, Institution of Mechanical Engineers (Great Britain), Institution of Mining Engineers (Great Britain), and the Society of Civil Engineers. He is a chevalier and officer of the French Legion of Honor, and has received several honorary degrees in the United States.

Herbert Hoover

Honorary Member 1929
John Fritz Medalist 1929

HERBERT Clark Hoover, famous engineer and president of the United States 1929–33, was elected to honorary membership in the Institute, June 25, 1929. During the same year, Mr. Hoover was awarded the John Fritz Medal. He received many other medals in the U.S. and other countries, and is a past-president of the American Institute of Mining and Metallurgical Engineers and of American Engineering Council. Mr. Hoover was born at West Branch, Iowa, August 10, 1874. In 1895 he received the degree of B.A. in mining engineering from Stanford University, Calif. Subsequently he has received many honorary degrees. During the period of 1895–1913 he was engaged in professional work in mines, railways, and metallurgical work throughout the world. In 1913–14 he represented the Panama-Pacific International Exposition in Europe. During 1914–15 he was in London, England, as chairman of the American relief commission, and in 1915–19, was chairman of the commission for relief in Belgium. During the period of 1917–19 he was also U.S. Food Administrator. He also served on several war boards and councils, and was director of various economic measures in Europe during the armistice. In 1919 he also was chairman of the American relief administration engaged in children's relief in Europe. In 1921 he was appointed U.S. Secretary of Commerce by President Harding, and was reappointed by President Coolidge. Mr. Hoover has served on many commissions in the United States.

Charles F. Brush

(A'84, M'84, member for life)

Honorary Memder 1929
Edison Medalist 1913

OVER a period of almost 60 years of activity, Charles Francis Brush was in the forefront as a pioneer in electrical development. He was born at Euclid, Ohio, March 17, 1849. While still at school, he became intensely interested in electrical apparatus. In 1869 he graduated in mining engineering from the University of Michigan, later securing the degree of M.S. at this university, followed by a Ph.D. from the Western Reserve University, Cleveland. One of the first to realize the value of the work of Gramme, in 1876, he designed and built a dynamo. The following year he introduced the compound field winding for obtaining constant voltage. It was at an exhibit in 1878 that he displayed the earliest form of what afterward became the world-famous Brush arc light machine. His, too, was the invention of the differential arc lamp, which made it possible to operate lamps in series, and of many other devices. In 1881 the Brush Electric Company was incorporated and capitalized at $3,000,000, being absorbed 10 years later by the General Electric Company, when the works were removed to Schenectady. Doctor Brush continued to develop much other apparatus, and contributed great improvement in the manufacture of storage batteries. He was a charter member of the Institute; he served in 1884–87 as one of the Institute's first managers, and was a member of the Edison Medal committee at the time of his death. On that date, June 15, 1929, his name was being voted upon for honorary membership in the Institute, and this distinction was conferred upon him by the board of directors 10 days after his death.

Motoji Shibusawa

(Associate 1905)

Honorary Member 1929

MOTOJI Shibusawa, dean of the faculty of engineering and professor of electrical engineering at the Tokyo (Japan) Imperial University, and also engineer of the Department of Communication, Japan, was elected an Honorary Member of the Institute on August 6, 1929. He was born, October 25, 1876, in Japan, and graduated in electrical engineering at Tokyo Imperial University in 1900. Following one year in the army service, he spent the period between 1901 and 1906 in study at different universities and in gaining practical experience at industrial plants, in several European countries and in the United States. Returning to Japan, he was appointed engineer of the department of communication in 1906, serving at the electrotechnical laboratory. In 1909 he was appointed to the additional post of engineer of the Imperial Railway Board. In 1911 he obtained the academic degree of doctor of engineering at the Tokyo Imperial University. In 1919 he was appointed engineer-in-chief, bureau of electricity, ministry of communication, and in that year he took the additional post of professor of the Tokyo Imperial University, to which later post he was definitely transferred in 1924. He was appointed dean of the faculty of engineering in 1929. Subsequently, he received promotions in both academic and business posts, and served the government on several special bureaus. In 1924 he was elected president of the Institute of Electrical Engineers, of Japan, and has been president of the Japan Electric Technical Committee, and has received many other honors

W. L. R. Emmet

(A'93, M'94, member for life)

Honorary Member 1933
Edison Medalist 1919

AT THE time William LeRoy Emmet began his career in the electrical industry some 50 years ago, he was noted for his desire to explore new fields of engineering, rather than to work in those in which considerable development work had been done. This characteristic has continued throughout his life. Doctor Emmet was born in Pelham, N. Y., July 10, 1859. In 1881 he graduated from the U.S. Naval Academy, remaining in the Navy for 2 years thereafter. In 1887 he joined the Sprague Electric Company, then engaged in the historic electric railway developments at Richmond, Va., and at other cities. After short periods with the Westinghouse Electric and Manufacturing Company and the Buffalo (N. Y.) Railway Company he went to Chicago as district engineer for the newly formed Edison General Electric Company. In 1892 he was transferred to the New York office of the company, which later became the General Electric Company. In 1900 Doctor Emmet started his work on the Curtis steam turbine, and he continued its development until recent years, when his attention turned to the mercury vapor power process in which activity he has again been singularly successful. He is now a consulting engineer of the General Electric Company. Doctor Emmet was elected an Honorary Member of the Institute May 22, 1933, and in 1919 received the Edison Medal. Other medals have been awarded him. He has served the Institute on several of its committees, and was vice-president 1900–02. He is also a past vice-president of the American Society of Mechanical Engineers.

G. A. Hamilton

(A'84, M'84, F'13, member for life)

Honorary Member 1933

GEORGE ANSON HAMILTON, one of the 6 living charter members of the Institute, vice-president 1884–86, and national treasurer for the 35-year period 1895–1930, was elected an Honorary Member of the Institute May 22, 1933. In addition to this unusual record of service, Mr. Hamilton served on the Edison Medal and executive committees for a great many years, and on the first editing committee and the committee on permanent quarters. He is the only surviving member of the original committee of 5 on organization. He is now retired, living at Elizabeth, N. J. Mr. Hamilton was born at Cleveland, Ohio, December 30, 1843. Between 1860 and 1873, he was in telegraph and railway signaling service. During 1873–75 he was assistant to Prof. Moses G. Farmer, an Honorary Member of the Institute, and a pioneer electrical inventor. Here Mr. Hamilton received much valuable experience. In 1875 he became assistant electrician of the Western Union Telegraph Company, New York, N. Y., being appointed chief electrician of the repair expedition of the Key West-Havana Cable the following year. In 1889 he became engineer for the Western Electric Company, New York, N. Y., supervising the production of fine electrical instruments. He retained this position until his retirement in 1909. Mr. Hamilton is a member of the Institution of Electrical Engineers (Great Britain), Société Française des Électriciens, Société Française de Physique, and Société Belge d'Astronomie.

R. A. Millikan

(Member 1922)

Honorary Member 1933
Edison Medalist 1922

ONE of the outstanding teachers and physicists of the present time was elected to honorary membership in the Institute when Dr. Robert Andrews Millikan was chosen May 22, 1933. Doctor Millikan was born at Morrison, Ill., March 22, 1868, and received the B.A. degree from Oberlin College in 1891, and that of Ph.D. from Columbia University in 1895. During the next year he attended the universities of Berlin and Göttingen. He has received many honorary degrees from universities in the United States and other countries. From 1891 to 1893 he tutored in physics at Oberlin College, and in 1896 became assistant in physics at the University of Chicago, becoming assistant professor in 1902; from 1906 to 1910 he was associate professor, becoming professor in the latter year. Since 1921 he has been director of the Norman Bridge Laboratory of Physics and chairman of the executive council of the California Institute of Technology, Pasadena. Doctor Millikan has conducted many fundamental experiments in physics which have been important contributions to present knowledge. He has recently become well known for his experiments on the so-called "cosmic" or Millikan ray, although his earlier experiments have been of much greater value to electrical engineers. In his work of instruction, he has evidenced rare ability to impart his own extraordinary scientific knowledge to others. He is a member of a large number of societies in the United States and other countries, having served as president of some of these.

George Westinghouse

(Associate 1902)

Edison Medalist 1911
John Fritz Medalist 1906

WHILE the fame of George Westinghouse rests largely upon his invention of the air brake and on the organization of tremendous manufacturing companies in the electric and related industries, he was responsible for the development of railway switch and signaling apparatus, the a-c system for lighting and power, a method for carrying natural gas over long distances, and many other devices. Not the least of his contributions was the environment which he created for many of the most outstanding electrical engineers and inventors of his day. His personal interest in their work and the inspiration and commercial impetus he gave to the development of such important advances in the art as Stanley's system of distribution of alternating current by transformers, Tesla's polyphase induction motor, the Shallenberger meter, and the Stillwell regulator resulted in epoch-making steps in the progress of civilization. Mr. Westinghouse was born in Central Bridge, N. Y., October 6, 1846. He attended Union College and served for 2 years on the North side of the Civil War. When, at 21, he announced to the authorities of the Pennsylvania Railroad at Pittsburgh, that he had invented an apparatus which would enable a locomotive engineer to completely control a train, he was laughed at, and it was several years before he could interest the company in the invention. Within a few years he founded the first of the various Westinghouse organizations with which he was actively associated until shortly before his death on March 12, 1914.

W. L. R. EMMET

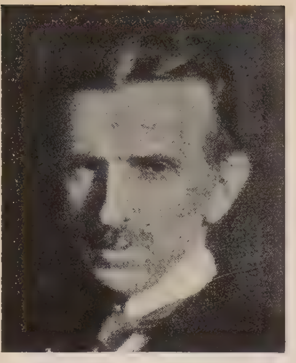
G. A. HAMILTON

R. A. MILLIKAN

GEORGE WESTINGHOUSE

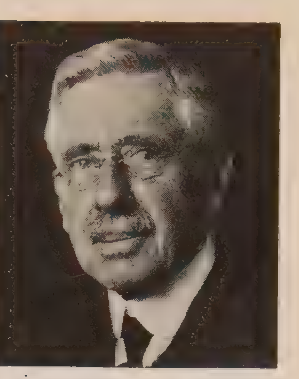
WILLIAM STANLEY

NIKOLA TESLA



B. G. LAMME

JOHN W. HOWELL



William Stanley

(A'87, M'98, F'13)

Edison Medalist 1912

WILLIAM STANLEY was very prominent among the electrical inventors and engineers who made possible long-distance light and power transmission; his inventions on the transformer and early work in the development of the a-c system contributed greatly to the advancement of the electrical art. During the earlier period of his career he was responsible for several incandescent lamp inventions, while in the employ of the United States Electric Company (1879–81) and the Swan Electric Company (1882–83). From 1883 to 1884 he experimented on storage batteries and other apparatus in a private laboratory at Englewood, N. J. He then became associated with the Westinghouse organization, and installed and equipped an incandescent lamp factory at Swissvale, Pa. In 1885, when because of illness he removed from Pittsburgh to Great Barrington, Mass., he set up a plant incorporating his ideas on long-distance light and power transmission, which distributed to the town 500 volts through transformers connected in multiple. The Westinghouse Company then took over the manufacturing details and installed the Stanley apparatus at Niagara Falls. In 1890 Mr. Stanley organized the Stanley Electric Manufacturing Company, which made the first of a long series of installations of the multiphase transmission system in 1894 at Housatonic, Mass., operating at 2,000 volts. In 1898 he organized the Stanley Instrument Company. He also carried on an extensive consulting practice, until his death on May 14, 1916. He served the Institute on the Edison medal committee, from 1914 to 1916. He was born November 22, 1858, in Brooklyn, N. Y.

Nikola Tesla

(A'88, F'17, member for life)

Edison Medalist 1916

IN THE days when a commercial rivalry existed between the supporters of the a-c and d-c systems, Nikola Tesla invented independently the polyphase a-c system and built the first small polyphase motor, inaugurating a new epoch in the electrical industry. His other discoveries and inventions are many, principally connected with apparatus for the use and transmission of power, such as the polyphase generator and transformer, oscillation transformer, revolving field generator, and split-phase motor, as well as high-frequency machines and coils, Tesla tubes, lamp and other high-potential high-frequency apparatus. Mr. Tesla was born in Smiljan, Lika, a borderland region of Austria-Hungary, and was educated at the Polytechnical School in Gratz and at the University of Prague. His electrical career began in 1881 when he was 24, at Budapest, where he made his first electrical invention, a telephone repeater, and conceived his idea of the rotating magnetic field. He came to the United States in 1884 and became a naturalized citizen. At first he was employed at the Edison works, and later by the Westinghouse Company, which purchased his patents on the polyphase a-c system and manufactured the motor. In 1890 he left the Westinghouse organization and began experimenting with high-potential, high-frequency alternating currents. In the last few years he has been working on a method to derive power in large amounts without regard to location.

Benjamin G. Lamme

(Associate 1903, Member 1903)

Edison Medalist 1918

FOR more than 30 years Benjamin Garver Lamme was an acknowledged leader in the invention and mathematical design of electrical apparatus particularly in the a-c field. Chief among his inventions of which the patents numbered more than 150, were the "umbrella" generators first used at Niagara Falls, the synchronous converter and the series commutator-type motor, which is now in use in street and other electric transit systems. Beginning in the testing department of the Westinghouse Electric and Manufacturing Company in 1889, he rose to distinction early through his remarkable ability to apply complex mathematical theorems to electrical apparatus: in 1890 he prepared specifications purely from calculation for a double-reduction railway motor. In 1900 he was made assistant chief engineer and from 1903 until his death July 8, 1924, he was chief engineer. Mr. Lamme was greatly interested in high-power generators and shortly before his death designed a 65,000-kw generator, the largest built to that date. He was born January 12, 1864, at Springfield, Ohio, and graduated in 1888 from Ohio State University with the degree of mechanical engineer. He served the Institute on many committees and represented it on the national committee of the International Electrical Congress (1919–21) and acted as chairman of the committee on inventions of the Naval Consulting Board in 1917. The Lamme medal was established by his bequest.

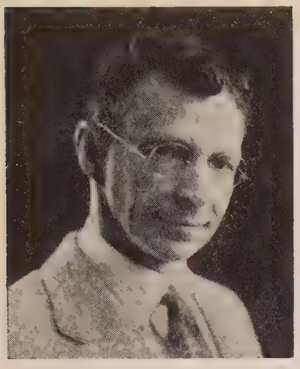
John W. Howell

(A'87, M'88, F'12, member for life)

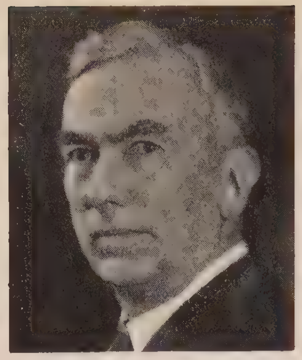
Edison Medalist 1924

ONE OF the most distinguished pioneers in the incandescent lamp field of electrical engineering is John White Howell, whose inventions and extensive research work have contributed greatly to the improvements and enlargement of incandescent lamp production. Among his important achievements are the development of a successful portable voltmeter, a wheatstone bridge type of potential indicator, and the comparative indicator. He determined for the first time the relation between the life and candle-power of incandescent lamps (1886); introduced a carbonaceous clamp which decreased clamping and filament costs and increased the quality of the lamp (1887) and later made certain changes to increase the speed of exhaust. He improved the Thomson-Houston method of treating carbon filaments and developed a treating machine which revolutionized the treating process, and introduced the squirted cellulose filament. He assisted in the design of the first stem-making machine and in the development of metalized filaments. He was born in New Brunswick, N. J., December 22, 1857. In 1881 he finished a special course in electrical engineering at Stevens Institute, receiving the honorary E.E. degree in 1899. He became identified with the Edison Lamp Company, beginning as electrician in 1881 and becoming technical advisor to the manager of works in 1890; in 1912, when the company was merged with the General Electric Company, he was made engineer and assistant manager of the lamp works. When he retired in 1931 his title was chief engineer of the lamp works. He is a member of The American Society of Mechanical Engineers, the Franklin Institute, and other technical societies.

W. D. COOLIDGE



FRANK CONRAD



EDWARD D. ADAMS

ELMER A. SPERRY

W. D. Coolidge
(A'10, M'34)

Edison Medalist 1927

AMONG electrical engineers engaged in the electrochemical and X ray fields, William David Coolidge holds an outstanding place. He is well known for his invention and application of ductile tungsten and for his development of a vacuum tube that has simplified and revolutionized the production of X rays. He is also the inventor of a submarine detecting device and of the Coolidge X ray tube. Doctor Coolidge was born at Hudson, Mass., October 23, 1873, and was graduated with the B.S. degree from Massachusetts Institute of Technology (1896), and Ph.D. from the University of Leipzig (1899). For 5 years he taught at the Massachusetts Institute of Technology as assistant in physics, instructor in physical chemistry and assistant professor of physicochemical research. In 1905 he joined the research laboratory of the General Electric Company, becoming assistant director in 1908, associate director in 1928, and director in 1932, which position he now occupies. Doctor Coolidge served the Institute as a member of the electrophysics committee from 1927 to 1929. He is a member of the American Electrochemical Society, American Physical Society; American Roentgen Ray Society, American Radium Society, Radiological Society of North America; Roentgen Society (England) and many others. He has been the recipient of several distinctive awards, notably the Washington award in 1932.

Frank Conrad
(Associate 1902)

Edison Medalist 1930

EVEN if he were not widely known for his contributions to radio broadcasting and short-wave radio transmission, Frank Conrad would be an outstanding figure in the electrical engineering world for his invention of numerous important electrical devices. He was born in Pittsburgh, Pa., May 4, 1874. At 16 he entered the employ of the Westinghouse Electric and Manufacturing Company in Pittsburgh as a shop assistant. On the strength of his first idea concerning a feeding mechanism for arc lamps, although rejected, he was taken into the experimental laboratory where he obtained an excellent foundation in physics and electricity. Within a short time he was busy on a long succession of inventions, including the "round type" arc lamp, long-scale induction indicating instrument, "round type" watthour meter, magnetic shunt and other switches, lightning arresters, and circuit breakers for use in a-c work, which are covered by more than 200 patents. He was closely associated with, and later in entire charge of, the arc-lamp design department. In 1904 he was appointed general engineer; since 1921 he has been assistant chief engineer. Doctor Conrad's connection with radio began with his interest as an amateur in the reception of time signals, and later in radio-telephone transmission. One of the few radio devices which saw war service was his 1,000-cycle 200-volt self-exciting generator for airplanes, weighing 11 pounds, encased with radio equipment and driven by a propeller. From 1919 to 1921 Doctor Conrad served the Institute as a member of the joint power factor committee. In 1928 the University of Pittsburgh awarded him the honorary degree of D.Sc. He is a fellow of the Institute of Radio Engineers and a member of the Society of Automotive Engineers and the American Society for the Advancement of Science.

Edward D. Adams
(Associate 1910)

John Fritz Medalist 1926

EDWARD Dean Adams is well known in the electrical field for his life-long connection with important engineering works and as an officer and director of corporations engaged in the construction and operation of water works, power plants, railroads, etc. He first became identified with the electrical industry by lending financial support to Edison's proposal to introduce electric lighting for streets and buildings in New York, about 1878. Next he became interested in the development of hydroelectric power at Niagara Falls. When electrical transmission was decided upon, Mr. Adams organized and became president of the Cataract Construction Company, which completed the project in 1895. He then turned his attention to the development, reorganization, and financing of numerous railroads, such as the St. Paul and Northern Pacific, Missouri Pacific, Northern Pacific, and West Shore. At various times he served as an officer of these and the many other utility, power and manufacturing organizations with which he was associated. Mr. Adams was born in Boston, April 9, 1846, and was educated at Norwich University, Vermont, receiving the B.S. degree (1864), M.S. (1897), LL.D. (1906) and M.A. (1908). He served the Institute on the Edison medal committee, 1919–24; and from 1916 until his death May 20, 1931, he represented the Institute on the Engineering Societies' library board and in the United Engineering Trustees, Inc. He was a member of the National Research Council, engineering and industrial research division, the American Society of Civil Engineers, and a vice-president of The American Society of Mechanical Engineers.

Elmer A. Sperry
(A'84, M'93, member for life)

John Fritz Medalist 1927

WHILE he had to his credit more than 400 patents, Elmer Ambrose Sperry is perhaps best known for his gyro-compass and ship stabilizer. Other inventions included his arc lamp, automatic current regulator, arc dynamo, motors, storage battery, high-intensity arc light, and searchlight. He was the originator of the first electric mining machinery and many new developments in the transportation line. Mr. Sperry was born at Cortland, N. Y., October 12, 1860. He was graduated from the State Normal School at Cortland and attended lectures at Cornell. The honorary degree of doctor of engineering was conferred upon him by Stevens Institute of Technology and Lehigh University, and doctor of science by Northwestern University. When he was only 19, he perfected one of the first electric arc lights and secured its practical adoption. Beginning in 1880, he organized numerous companies bearing his name to perfect and manufacture his inventions, one of the last being the Sperry Development Corporation, which he sold in 1929 to the Curtiss air interests. At the time of his death, June 16, 1930, he was the proprietor of Sperry Products, Inc. He was a charter member of the Institute and served as a member of the marine, research, Edison medal, and Lamme medal committees at various times. He was a member of a number of other societies, including the Electrochemical Society, of which he was a charter member, and The American Society of Mechanical Engineers, and was the recipient of several prizes and distinctions, both national and foreign.

Allan B. Field

(A'03, M'09, F'13, Life Member)

Lamme Medalist 1928

THE first Lamme Medal to be presented by the A.I.E.E. was awarded Allan Bertram Field in 1928 "for the mathematical and experimental investigation of eddy current losses in large slot-wound conductors in electrical machinery." Mr. Field was born in New Barnet, England, December 28, 1875. He studied at Finsbury Technical College, London, 1890–93. After being engaged in shopwork and drafting, he studied at St. Johns College, Cambridge, 1896–99, and was awarded the Honours B.A. degree, and later the M.A. and Honours B.Sc. degrees. During 1900–02, he was engaged in engineering work for the British Thomson-Houston Company in London. He came to the United States in 1902, spending more than a year in the testing department of the General Electric Company at Schenectady, N. Y., afterward being engaged in transformer design. During 1905–08, he was with the Bullock Electric Manufacturing Company, and the Allis-Chalmers Company in the design of a-c generators and motors. In 1909 he joined the Westinghouse Electric and Manufacturing Company, being appointed engineer-in-charge of turbine generator design in 1911. In 1914 Mr. Field returned to England, becoming consulting engineer and professor of mechanical engineering at the University of Manchester, retaining this position until 1917 when he went with Vickers, Ltd., London. In 1920 he became and still is consulting engineer for the Metropolitan-Vickers Electrical Company, Ltd., Manchester, England.

R. E. Hellmund

(A'05, M'09, F'13)

Lamme Medalist 1929

THE second individual to be awarded the Lamme Medal of the Institute was Rudolf Emil Hellmund. Mr. Hellmund is widely known for his inventive genius, some 300 patents in the United States and other countries having been granted him. He was born at Gotha, Germany, February 2, 1879. He graduated from the Technical Institute of Ilmenau, Germany, worked 3 years, then continued his studies at Charlottenburg University, Berlin, graduating in 1899 with the degree of electrical engineer. After being engaged in the development work in Germany, he came to the United States in 1903. After doing other engineering work, he was associated in 1905 with William Stanley at Great Barrington, Mass. During 1905–07, he was in the engineering department of the Western Electric Company at Hawthorne, Ill., in charge of all a-c motor design for the company. Since October 1907, he has been with the Westinghouse Electric and Manufacturing Company. After being in charge of the development of various kinds of induction motors, he was placed in charge of all designs of d-c and a-c railway motors. In 1907 he was assigned miscellaneous consulting duties, and in 1921 was appointed engineering supervisor of development. In 1926 he was made chief electrical engineer and in 1933 was given the position of chief engineer of the company. Mr. Hellmund has presented many papers before the Institute and has been a member of the standards committee since 1930. In the past 2 years he has devoted much attention to the development of air conditioning equipment.

William J. Foster

(Associate 1907, Fellow 1916)

Lamme Medalist 1930

THE Institute's Lamme Medal for 1930 was presented to William James Foster "for his contributions to the design of rotating a-c machinery." Doctor Foster has a long record of service in the design of motors and generators and has been responsible for a great many inventions in this field. He was born at Argyle, N. Y., September 17, 1860. After receiving the A.B. degree from Williams College in 1884, he remained a year for advance work in mathematics. During the next 5 years, he taught high school subjects, and made an intensive study of physics. In 1891 the degree of M.S. was conferred upon him by Cornell University. In the summer of that year Doctor Foster began his engineering career in the Thomson-Houston works at Lynn, Mass., being engaged in the design of d-c machines and synchronous converters. In 1892 he was made assistant engineer. In 1894 he became designing engineer for the General Electric Company at Schenectady, in general charge of electrical design of a-c machines. For about 25 years thereafter he was in charge of practically all the designs and calculations on a-c machines, he himself designing many of the most important generators that were built by the company. Through Doctor Steinmetz, with whom he worked closely for many years, he prepared many of the standards adopted by the A.I.E.E. Doctor Foster is now consulting engineer (retired) for the General Electric Company, and lives at Schenectady. He was a member of the Institute's committee on electrical machinery 1920–30 (chairman 1928–29), and of the meetings and papers (now technical program) committee 1928–29.

Guiseppe Faccioli

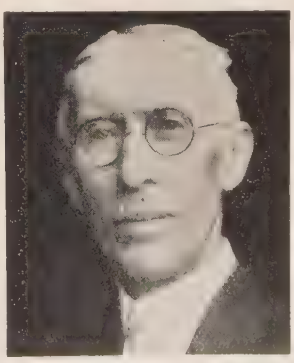
(A'04, M'11, F'12)

Lamme Medalist 1931

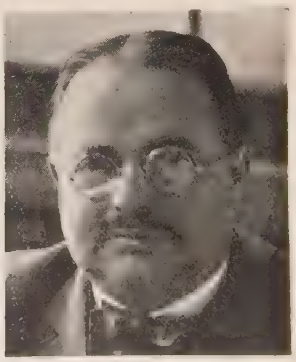
"FOR his contributions to the development and standardization of high-voltage oil-filled bushings, capacitors, lightning arresters, and numerous other features in high-voltage transformers and power transmission," Guiseppe Faccioli was presented the 1931 Lamme Medal of the A.I.E.E. He was born at Milan, Italy, April 7, 1877. Graduating from the University of Milano in 1899 with the highest scholarship, he was engaged for one year in the electrification of a locomotive factory, spent one year in the testing room and in charge of the design of induction motors and alternators for the Tenomasio Brown Boveri of Milano, was engaged as a consulting engineer for one year, and then in 1902 came to the United States. Between 1902 and 1906 he had a varied experience, being with the Interborough Rapid Transit Company, New York, the Crocker-Wheeler Company, and an assistant to William Stanley at Great Barrington, Mass. In 1906 he began his long term of service with the General Electric Company. He continued at the Great Barrington laboratory until 1908, when he was transferred to the railway department at Schenectady, later the same year being transferred to the transformer department, and in 1911 appointed assistant engineer of the transformer department. Later he was transferred to the Pittsfield works, and in 1913 was appointed work's engineer of this plant. In 1927 he also became associate manager, retiring in 1930. His death occurred January 13, 1934. Mr. Faccioli had served the Institute as manager 1918–22, and as vice-president 1922–24. He had also served on many committees of the Institute.

ALLAN B. FIELD

R. E. HELLMUND



W. J. FOSTER



GUISEPPE FACCIOLI

The Institute's National Secretaries

N. S. Keith

(Associate 1884, Member 1894)

Secretary 1884–85

THE FIRST secretary of the Institute was Doctor Nathaniel Shepard Keith, one of the most active of the small group of individuals who founded the Institute. Doctor Keith served as secretary during 1884 and 1885. It was he who circulated the "call" for the first meeting of what was to be the American Institute of Electrical Engineers.

Doctor Keith was born at Boston, Mass., July 14, 1838. He was educated as a chemist in his father's chemical laboratory in New York City, and maintained practice as an electrometallurgical engineer the larger part of his life. The early years of his life were spent as a mining and metallurgical engineer in Colorado. For many years following 1870, he was engaged in electrical work as an investigator, inventor, writer, and electrical engineer. For some time following 1885 he was engaged in the manufacture and installation of electric light and power apparatus in San Francisco. He was at one time secretary-treasurer of the American Venture and Mines Corporation. For many years preceding his death, January 27, 1925, Doctor Keith had been in business in Philadelphia as a consulting engineer.

During the first 2 years of the Institute's history Doctor Keith was a member of the editorial staff of the *Electrical World*, along with C. O. Mailloux and T. C. Martin, both of whom subsequently became presidents of the Institute. Doctor Keith was one of the conferees of the Electrical Conference in Philadelphia, in 1884, and a judge of the Philadelphia Electrical Exhibition in that year.

T. Commerford Martin,
Acting Secretary 1884–85

DURING the period 1884–85, while Dr. N. S. Keith was serving the Institute as secretary, Thomas Commerford Martin (president of the Institute 1887–1888) served as acting secretary. A biographical sketch of Mr. Martin is given in connection with the group of presidents in this issue.

Ralph W. Pope

(A'04, member for life)

Secretary 1885–1911

OVER a period of nearly 27 years, Ralph Wainwright Pope served the Institute as its secretary. He was first elected in 1885, and served each year consecutively from that time until 1911, when he was appointed honorary secretary for life. Mr. Pope was a younger brother of Franklin L. Pope, second president of the Institute.

Ralph W. Pope was born at Great Barrington, Mass., August 16, 1844. He was educated at Amherst Academy. Early in life he developed a marked taste for mechanics. After early experience in the local telegraph office, he entered the service of the Housatonic Railroad in 1859, becoming a telegrapher. After being in various telegraph offices of this road, he entered the service of the American Telegraph Company in 1864, being in the New York office. In 1865 he joined the Collins Overland Telegraph Expedition in an attempt to establish a through service to Europe by way of Alaska and Siberia. It was this expedition of which Franklin L. Pope was chief of the geographical department; the success of the Atlantic cable prevented the establishing of this connection. Ralph W. Pope was for 10 years thereafter in the service of the Gold and Stock Telegraph Company, resigning his position as deputy superintendent in 1883. From that date until 1888 he was actively engaged in the editing and publishing of technical electrical papers in New York City. He was associate editor of *The Telegrapher* and *The Electrical Engineer*, and editor of *Electric Power*, which he founded.

During his tactful administration, the growth of the Institute was rapid. In 1887, he consented to devote practically all of his time to its interests alone. He made a constant study of its needs, and did not hesitate to recommend the adoption of all that appealed to him as desirable in the methods and activities of other technical organizations. His clear conception of detail, his genius for taking pains, and the orderly methods of his office, all were extremely valuable in his position as secretary.

F. L. Hutchinson

(A'94, M'13, member for life)

Secretary 1911–32

UPON the resignation of Ralph W. Pope in August 1911, Frederick Lane Hutchinson was appointed acting secretary, being later appointed secretary as of January 1, 1912.

Mr. Hutchinson was born at Elizabeth, N. J., April 2, 1866. He began his business experience with several years' service with the Pennsylvania Railroad Company in New York City, later entering Cornell University in 1889. In 1893 he graduated from the electrical engineering course, and immediately entered the employ of the Westinghouse Electric and Manufacturing Company. After several years' experience in the manufacturing, testing, engineering, and sales departments in Newark, N. J., New York City, and Pittsburgh, Pa., he was transferred to the publication department.

In 1901 he became manager of the publication department of the C. W. Hunt Company, New York, and in the following year became advertising manager of the National Electric Company of Milwaukee, Wis. A year later he was made manager of electrical sales for the same company.

Mr. Hutchinson returned to New York in 1904 to undertake some special work on the TRANSACTIONS of the Institute. This work gradually increased in scope until in February 1908 he was appointed assistant secretary, becoming the national secretary at the beginning of 1912. Mr. Hutchinson served in this capacity continuously until his death, February 26, 1932.

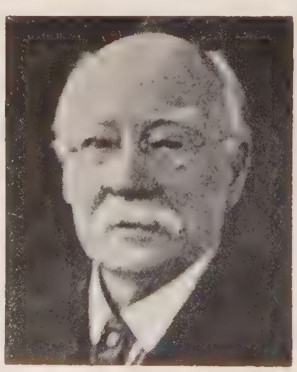
Mr. Hutchinson was thoroughly familiar with the history and policies of the Institute, the scope and duties of its numerous committees and representatives, and the relations of the Institute to other engineering and similar organizations, both in this country and abroad. He was one of the delegates to the World Power Conference, London, 1924, and to the World Engineering Congress, Tokyo, 1929. He had served on various Institute committees, both before and after becoming secretary. Immediately prior to his death he was a member of the committees on publications, coördination of Institute activities, award of Edison Medal, and maintenance of Institute headquarters. He was also a representative of the Institute on several other bodies. During Mr. Hutchinson's term as secretary, the Institute's membership increased $2^1/_2$ times.

H. H. Henline

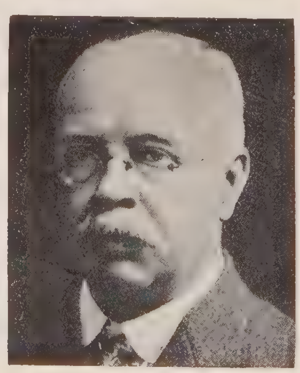
(Associate 1919, Member 1926)

Secretary 1932–

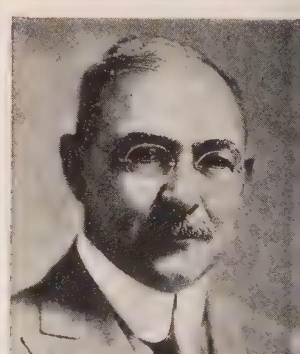
THE PRESENT national secretary of the Institute is Henry Harrison Henline. Mr. Henline became assistant na-



N. S. KEITH



RALPH W. POPE



F. L. HUTCHINSON

tional secretary in 1927, and upon the death of F. L. Hutchinson in 1932, he became acting national secretary. Effective January 1, 1933, he was appointed national secretary, taking over all the executive duties that had been performed by Mr. Hutchinson for 20 years.

For many years Mr. Henline has been active in Institute work, and prior to his affiliation with the national headquarters staff, he made numerous contributions to its published technical work. These included papers on engineering education, a standard frequency radio station, and high voltage power transmission. He has served as chairman of the San Francisco section (1922–23); faculty counselor for the Student Branch at Stanford University, Calif. (1926); chairman of the committee on student activities for the Pacific district (1926); and as a member of the Sections committee (1923–27). Since joining the headquarter's staff in 1927, Mr. Henline has served as a member of 6 of the Institute's committees, and has been a representative of the Institute on 6 other bodies. He is at present active on most of these.

As assistant secretary, Mr. Henline participated in many phases of the Institute's work, but devoted his principal attention to the work of its many Sections and Branches.

Mr. Henline was born at Colfax, Illinois, March 12, 1889, graduating in 1914 from the University of Illinois, with the degree of B.S. in E.E. After serving for a year as instructor in science and mathematics in the Oktaha (Okla.) High School and as director of athletics for the public schools there, he entered the Chicago Central Station Institute of the Commonwealth Edison Company. In 1916 he entered the commercial Engineering department of the Illinois Maintenance Company of Chicago.

Joining the faculty of Stanford University in 1917 as an instructor, Mr. Henline later was promoted to assistant professor (1920) and to associate professor (1924) in the department of electrical engineering. In his work of instruction Mr. Henline gave at various times many courses in electrical engineering subjects, and was in charge of the machinery laboratory for 5 years, and in charge of communication engineering for 3 years. He also was associated with Dr. Harris J. Ryan in some of the high voltage research that has been carried on so energetically at Stanford University.

The Institute's National Treasurers

Rowland R. Hazard
(Associate 1884)

Treasurer 1884–86

THE INSTITUTE'S first treasurer was Rowland Robinson Hazard. Mr. Hazard was a charter member of the Institute, and at the time of its formation was president of the Gramme Electric Company, of New York City. He presented a paper, "The Scientific Street," at the Institute's first technical meeting, October 7–8, 1884. About 5 years ago Mr. Hazard died at his home on the Island of Jersey, England, where he had lived many years. He was over 90 years of age.

George M. Phelps
(Associate 1884)

Treasurer 1887–95

THE SECOND treasurer of the Institute was George May Phelps, who served continuously from the time of his first election to that office on May 17, 1887, until his death on April 11, 1895.

Mr. Phelps was born at Troy, N. Y., in 1843. He was educated in the public schools and high school of that city. From 1861 until his death he was continuously engaged in electrical interests, excepting for an interval of 5 years. He was first employed in the shop of the American Telegraph Company, of which his father was superintendent. He afterward served in the auditing department of the American Telegraph Company from 1863 to 1866. From 1871 to 1879, he was assistant to his father in the management of the factory of the Western Union Telegraph Company in New York City. In April 1879, the Western Union disposed of its manufacturing interests to the Western Electric Company, and Mr. Phelps was appointed superintendent of the factory by the latter organization, which position he held until December 1885. In 1886, he joined Franklin L. Pope, who was then president of the Institute, in conducting *The Electrician and Electrical Engineer*, at that time published monthly, acquiring a proprietary interest in that journal shortly after. The title was subsequently changed to *The Electrical Engineer*, and, beginning in 1890, was issued weekly, with Mr. Phelps as president.

Mr. Phelps was a charter member of the Institute and was elected as one of its managers on May 19, 1885. He served on the council in this capacity until his election as treasurer. He also had served on various standing and special committees, and had at all times given readily of his time and services to the interests of the Institute.

George A. Hamilton
(A'84, M'84, F'13, HM'33, member for life)

Treasurer 1895–1930

THE THIRD treasurer of the Institute was George Anson Hamilton, a charter member of the Institute. A biographical sketch of Mr. Hamilton is given on p. 816 of this issue, in connection with his election as an Honorary Member, and a recent statement of his is given on p. 823.

W. I. Slichter
(A'00, M'03, F'12)

Treasurer 1930–

THE FOURTH and present treasurer of the Institute is Walter Irvine Slichter, who has served since 1930. He is now professor of electrical engineering and head of the department at Columbia University.

Professor Slichter was born in St. Paul, Minn., May 7, 1873, and graduated from Columbia University in 1896, with an E.E. degree. He entered the employ of the General Electric Company as a student in that year, being transferred to the office of Dr. C. P. Steinmetz the following year. During the next 2 years he was engaged in designing induction motors, alternators, rotary converters, transformers, and special experimental apparatus. For a number of years thereafter he devoted most of his time to the design of electrical machinery, and, more particularly, the equipment of electric railways. In 1910 he was appointed to his present position as professor of electrical engineering and head of the department at Columbia. During the war, he was civilian director of the air service school for radio officers at Columbia.

Professor Slichter was a member of the Institute's board of directors 1918–22, vice-president 1922–24, and has been an active worker upon several of the important committees of the Institute. He has been chairman of the meetings and papers committee, of the editing committee, and a member of the finance committee. He is a member of several other engineering and scientific societies, and in 1903 was president of the General Electric Engineering Society, and was instrumental in reorganizing it into the Schenectady Section of the Institute.

H. H. HENLINE

GEORGE M. PHELPS

W. I. SLICHTER

Formation of the Institute and the Enrolling of Its Charter Members

"WE LEARN that a movement has been inaugurated for the formation of a national electrical society, and that several distinguished men connected with the science and with electrical enterprises have promised it their warmest support. The idea is admirable, and cannot but succeed. It is said that details will shortly be made public." This simple statement, presaging the founding of the Institute, appeared in the *Electrical World* for March 29, 1884.

The first definite steps toward the formation of a society were taken in April 1884, when Dr. N. S. Keith, electrical engineer, New York City, circulated a "call" for the purpose of establishing a national electrical society to which it was suggested to give the name of the "American Institute of Electrical Engineers." This "call" outlined the principal reasons for the formation of a society, and outlined the activities which it was proposed to undertake. The activities mentioned in this early document are almost identical with those on which the Institute today is engaged. The pioneers in the electrical industry who organized the Institute had a remarkably clear vision as to what it might accomplish for the benefit of its members and of society in general.

Although the "call" had proposed that an organization meeting be held on May 13, 1884, the document was so quickly signed by a large number of electrical engineers, then commonly known as "electricians," capitalists, and others connected with electrical enterprises or interested in the advancement of electrical science, that it was deemed advisable to hold a meeting on April 15, 1884. The signers of this document, and a number of other individuals who had expressed interest, were requested to meet on that date at the rooms of the American Society of Civil Engineers, New York, as founders of the proposed society.

Meeting of April 15, 1884

The meeting of April 15, 1884, was called to order by Dr. N. S. Keith, who nominated Joseph P. Davis, vice-president of the Metropolitan Telegraph and Telephone Company, as chairman of the meeting. After Mr. Davis took the chair, Dr. Keith was elected temporary secretary.

A series of resolutions as to name, object, membership, dues, management, committees, etc., was then offered, and after some debate, the resolutions and the whole scheme of organization were referred to a committee of 5, with instructions to call a meeting to hear and act upon its report. The chair afterward appointed the committee, consisting of the following:

W. A. Hovey, president, Merchants' Electric Light Company, Boston.
N. S. Keith, electrical engineer.
G. A. Hamilton, electrician, Western Union Telegraph Company.
William H. Eckert, general superintendent of the Metropolitan Telephone and Telegraph Company.
George L. Beetle, Western Electric Company.

After a vote of thanks to the American Society of Civil Engineers for the use of its rooms, the meeting adjourned.

Meeting of May 13, 1884

The organization meeting of the Institute, held May 13, 1884, was presided over by Joseph P. Davis. Following a reading and approval of the minutes of the April 15 meeting, the committee on organization reported that it had completed a proposed set of rules for the government of the Institute and had nominated a sufficient number of persons to fill the offices created. The rules were then read and adopted, the election was held, and the results announced. The Institute then had a permanent organization, with a complete set of officers.

With the organization completed, the first piece of business was undertaken, which consisted of the reading of a communication from the examiner in the electricity division of the U.S. patent office, pointing out various evils in patent procedure; a resolution urging that the work of the patent office be put on a more efficient basis was then passed, and a committee of 3 was authorized to promote this endeavor.

Following a discussion of the state of electric lighting on the Pacific Coast, resolutions thanking the American Society of Civil Engineers for the use of the rooms and thanking the organization committee, were passed, and the meeting adjourned.

Philadelphia Meeting, 1884

One of the factors which precipitated the founding of the Institute in 1884 was the International Electrical Exhibition to be held in the fall of that year in Philadelphia under the auspices of the Franklin Institute. In conjunction with this exhibition, the U.S. Congress had authorized a National Conference of Electricians. Representatives of many foreign electrical societies were to attend the exhibition, and it was felt essential that there be some organization of electrical engineers in the United States to officially receive these delegates.

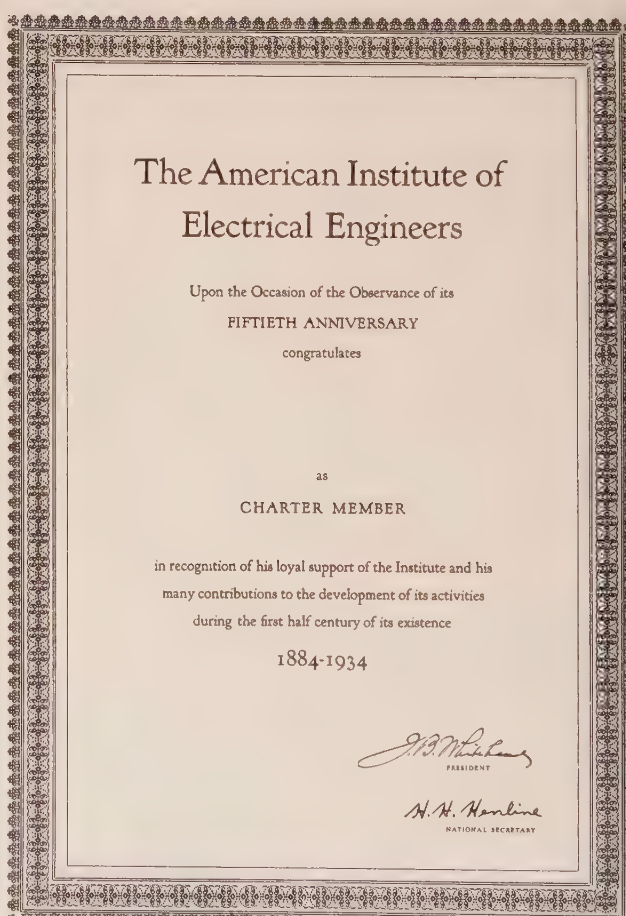
The directors of the International Ele trical Exhibition tendered to the Institu the use of rooms in the exhibition buildin these rooms being open to Institute membe from September 2 to October 11. C October 7 and 8, 1884, the first meeting the Institute for the reading and discussic of professional papers was held at the Cont nental Hotel and in the exhibition room Eleven papers were read at these meeting several of which have since become histor documents.

Annual meetings were then held in Ma 1885 and in May 1886, when the develo ment of a system of more frequent meetin was begun. Subsequent developmen have, of course, included the holding several national meetings each year, wit Section and Branch meetings held man times a year in all sections of the Unite States.

The Institute's Charter Members

Analysis of the records of the Institut definitely indicates that at least 71 chart members were enrolled at the meeting April 15, 1884. In addition to these, is possible that there were a few more charte members, as accurate records were not a ways kept at that time.

Of these 71 charter members, 6 are sti



The American Institute of Electrical Engineers

Upon the Occasion of the Observance of its

FIFTIETH ANNIVERSARY

congratulates

as

CHARTER MEMBER

in recognition of his loyal support of the Institute and his many contributions to the development of its activities during the first half century of its existence

1884-1934

PRESIDENT

H. H. Henline

NATIONAL SECRETARY

Certificate to be awarded the 6 living charter members of the Inst tute during the 1934 summer convention, June 25–29, at H Springs, Va.

on the rolls of the Institute. These are: Charles L. Clarke, Schenectady, N. Y.; E. N. Dickerson, Jr., New York, N. Y.; George A. Hamilton, Elizabeth, N. J.; Frank B. Rae, Berkeley, Calif; Elihu Thomson, Lynn, Mass.; and Edward Weston, Newark, N. J. Biographical sketches of Mr. Hamilton, Professor Thomson, and Doctor Weston, have been given in connection with the items on Presidents and Honorary Members on preceding pages of this issue. Brief items on the other 3 living charter members follow, together with statements prepared by Mr. Clarke and Mr. Hamilton.

Charles L. Clarke

Charles Lorenzo Clarke (A'84, M'85, F'12, member for life) a charter member of the Institute, and now a consulting engineer living at Schenectady, N. Y., was born at Portland, Maine, April 16, 1853. In 1870 he began civil and railroad engineering, becoming first assistant engineer on the old Boston and Maine Railroad, but gave up this position to enter Bowdoin College, from which he received the degrees B.S., 1875; M.S., 1879; and C.E., 1880. During part of this period he was designer and draftsman in various steel manufacturing plants. In 1880 he entered the laboratory of Thomas A. Edison, at the time Mr. Edison invented the incandescent electric lamp, as mathematical assistant. However, Mr. Clarke quickly engaged in experimental, testing, and research work and then designing of electrical generators and other apparatus for Mr. Edison's first commercial system of lighting. In 1881, he was chief engineer of the parent Edison Electric Light Company, and had engineering charge of the pioneer development and installation of the first system for central station and isolated plant lighting, organized and managed the engineering staff and research and testing departments, and was consulting engineer of the allied operating companies. Between 1884 and 1887 he was engineer for the Telemeter Company, New York, and for the next 2 years was with the Gibson Electric Company, engaged in the development of storage batteries. Between 1889 and 1901 he was in consulting engineering practice and on patent work. In 1901 he became consulting engineer and patent expert in the board of patent control of the General Electric Company and the Westinghouse Electric and Manufacturing Company, and in 1913 became consulting engineer on the staff of the General Electric Company at Schenectady. Mr. Clarke held this position until his retirement in 1931. Mr. Clarke's position as one of the outstanding pioneers of the electric industry is justified by his work on the design of the famous Jumbo machine installed on early Edison systems, and his supervision of the installation of the Jumbo machines and other equipment in the also famous Pearl Street station in New York.

A Statement From Mr. Clarke

Mr. Clarke has contributed a statement for this anniversary issue of Electrical Engineering, in which he expresses briefly his feelings in respect to the past and present of the Institute, and the true status of the so-called machine age in which Institute members are so vitally concerned. Mr. Clarke's statement follows:

"On this 50th anniversary in the life of the American Institute of Electrical Engineers, a charter member is naturally in reminiscent mood to compare the early with the present status of the organization, which at the end of 3 years after its founding counted only about 30 members, with no assets now worth mentioning, and has phenomenally prospered, with a present membership of 15,200, with assets amounting to some $800,000. This material growth symbolically bespeaks the value of the past accomplishments of the Institute for the welfare of electrical engineers, and in turn, the obviously great worth of their service to society at large. The outcome of that service is seen and in use on every hand, both day and night, on a scale which in the aggregate is so immense as to be almost beyond reckoning, it may quite truly be said.

CHARLES L. CLARKE

"Included in major activities of members of the Institute have been the creating and applying of electric machines largely for operating in conjunction with other machines, to lessen labor, or increase and lessen cost of production, or both. The members are historically acquainted with the long-ago periodical, unthinking agitations against and sometimes forceful opposition to, the use of these machines for these purposes. This objection to machines had died down, and was practically non-existent when the Institute was founded.

"But in the last 50 years, charter members, and other members in more recent years, have seen a phenomenal increase in use of such so-called labor saving machines, which has given opprobrious rise to the term 'machine age,' and much comparatively recent misdirected agitation against this alleged condition, on the ground that labor has become the slave of the machine, which is patently an incorrect conception of the true situation.

"Machines have neither souls nor hearts, thus can neither be soulless nor heartless, like some human beings. Nor can they make slaves of men, as can other men, who sometimes do so. Machines are but inert material tools in the hand of man, for him to use for a good purpose, or possibly for bad, if such be his disposition and intent. In this sense, no more and no less, they are exactly like the generally simple tools of man in early centuries. So it comes to this: that the welfare of society depends upon the acts of man toward man, fair or foul, just or unjust, machine or no machine. There can be no such condition as a machine age in a sense invidious to the machine. It may be made to do a great good, but of itself can harm no one.

"Let not any member of the Institute be misled into discouragement by revival of the old agitation against machines; but let him keep on improving the old and adding to the number of new machines—all useful when under wise management, that has a heart and soul, and a moral interest in the just welfare of all men in all stations of life."

E. N. Dickerson

Edward Nicholl Dickerson (A'84, member for life), electrical engineer and patent attorney, was born at Newport, R. I., August 23, 1852. He is a son of E. N. Dickerson, Sr., who in the period of about 1850 and 1860, was probably the outstanding patent attorney in the United States. E. N. Dickerson, Jr., the charter member of the Institute, graduated from Trinity College with the degree of A.B. in 1874, and from Columbia Law School with the degree of LL.B. in 1876. His principal activity has been the practice of patent law, which he has maintained in New York. During the early days of the Institute while it was active in an attempt to secure improved patent procedure, Mr. Dickerson suggested methods of providing reforms. He is a member of many clubs and associations in New York, several of them connected with the legal profession.

Mr. Hamilton's Statement

A brief statement prepared by George A. Hamilton for this anniversary issue of Electrical Engineering follows. A biographical sketch of Mr. Hamilton, who served the Institute as its national treasurer over a 35-year period, and who was elected an Honorary Member of the Institute in 1933, is given on a preceding page of this issue.

"The Institute is now celebrating its 50th anniversary. The occasion naturally turns our attention to its earlier days, and the following brief references thereto may not be without interest.

"In the early eighties there was much activity in electrical matters, new industries were coming to the front, and old ones expanding. In this connection the growing desire for some authoritative body to deal with the technical side of questions was felt, and on the initiative of N. S. Keith a meeting of those interested was called to consider the matter. The final outcome resulted in the organization of the Institute, with Dr. Norvin Green as president.

"Under the favorable conditions the new body grew and prospered, slowly at first, and more rapidly later. By 1920 its rolls listed 10,000 members and by 1930 over 18,000.

"Members sometimes met at dinner for discussion and informal talks.

"The first 3 or 4 years few papers were published but since there has been no dearth of papers as attested by the well-filled volumes of the PROCEEDINGS.

"I have enjoyed my membership in the Institute as well for the social pleasures as for the technical information it has brought me, for the new acquaintances formed, and for the more frequent opportunities of meeting old ones, numbers of whom, alas, are no longer with us."

Frank B. Rae

FRANK BENJAMIN RAE (A'84, M'20, member for life) another of the 6 living charter members, was born at Elmira, N. Y., July 25, 1854. Mr. Rae is self-educated. During the period of 1870 to 1881, he was in the telegraph service as messenger, operator, and manager of the Atlantic and Pacific Telegraph Company and the Western Union Telegraph Company. In 1881 he resigned from the position of electrician at San Francisco for the latter company and became engineer for what was then the Brush Electric Light Company, San Francisco, and manager of the San José (Calif.) Brush Electric Company. In 1883 he became engineer for the Commercial Telegram Company (stock quotations) at New York. During the period of 1885–87 he was a consulting engineer at New York, as a member of the firm of Mailloux and Rae. In 1887 he was consulting engineer for the Barker Syndicate in China, and during 1887–92 was engineer for the Detroit (Mich.) Electrical Works, engaged on the Rae Electric Railway System. Since 1892 he has been a consulting electrical engineer, being at Detroit, Mich., 1892–95; Chicago, Ill., 1895–1900; New York, N. Y., 1900–05; Detroit, 1905–10; New York, 1910–13; Cleveland, Ohio, 1913–19; and San Francisco, 1919–23. In 1923 he became electrical engineer for the city of Berkeley, Calif., resigning in 1930. Mr. Rae holds a total of about 100 patents.

List of Charter Members

In addition to the 6 living charter members just mentioned, there were 65 other charter members who are no longer living. Biographical sketches of 13 individuals in this latter group are given in associated pages of this issue. Six of these served the Institute as presidents, 3 were elected to honorary membership, 1 was awarded the John Fritz medal, while 1 charter member served the Institute as secretary, and 2 as treasurers.

A list of all who have been definitely determined to have been charter members of the Institute follows. For those who are mentioned in biographical sketches in this issue, reference to the page number where the sketch appears is given after the name.

Adams, H. C., New York Agent, Fort Wayne Jenney Elec. Lt. Co., New York, N. Y.

Bates, D. H., Pres., B. & O. Tel. Co., New York, N. Y.

Bell, Prof. A. Graham, Washington, D. C. (p. 791)

Berliner, Emile, Inventor, Washington, D. C.

Bosch, Adam, Supt., Fire Alarm Telegraph, Newark, N. J.

Brush, Chas. F., Elec. Engr., Cleveland, Ohio. (p. 815)

Buckingham, Chas. L., Counsel, Western Union Tel. Co., New York, N. Y.

Cheever, Chas. A., New York, N. Y.

Chinnock, C. E., Edison Elec. Illuminating Co., New York, N. Y.

Clarke, Charles L., Elec. Engr., Gibson Electric Co., New York, N. Y. (p. 823)

Cleveland, Wm. B., Elec. Engr., Cleveland, Ohio.

Cross, Chas. R., Thayer Prof. of Physics, and Director of the Rogers Lab., Mass. Inst. of Tech., Boston, Mass.

Curtis, Chas. G., New York, N. Y.

Dana, R. K., Agent, Washburn and Moen Mfg. Co., New York, N. Y.

Davis, Jos. P., Vice-Pres., Met. Tel. and Tel. Co., New York, N. Y.

Delaney, P. B., Synchronous Multiplex Telegraph, New York.

Dickerson, E. N., Jr., Electrician and Counsel in Patent Causes, New York, N. Y. (p. 823)

Diehl, Philip, Inventor, Singer Sewing Machine Co., Elizabeth, N. J.

Durant, Geo. F., Vice-Pres. of Bell Tel. Co. of Mo., St. Louis, Mo.

Edison, Thomas A., Inventor, Orange, N. J. (p. 814)

Emmet, Herman L. R., Publisher and Printer, New York, N. Y.

Farmer, Prof. Moses G., Electrician and Inventor, Eliot, Me. (p. 811)

Field, Stephen D., Electrician, Commercial Tel. Co., New York, N. Y.

Gilliland, E. T., Vice-Pres., Empire City Elec. Co., New York, N. Y.

Green, Norvin, Pres., Western Union Tel. Co., New York, N. Y. (p. 788)

Hall, Clayton C., Civil Engr., Baltimore, Md.

Hamilton, George A., Electrician, Western Union Tel. Co., New York, N. Y. (p. 816)

Haskins, Charles D., Elec. Engr., Western Elec. Co., New York, N. Y.

Hazard, Rowland R., Pres., Gramme Elec. Co., New York, N. Y. (p. 821)

Healy, Clarence L., Supt. and Electrician, Commercial Telegraph Co., New York, N. Y.

Hebard, George W., Pres., United States Elec. Lt. Co., New York, N. Y.

Hochhausen, William, Pres., Excelsior Elec. Co., Brooklyn, N. Y.

Houston, Prof. Edwin J., Electrician, Thomson-Houston Co., Lynn, Mass. (p. 792)

Johnston, W. J., Publisher of *The Electrical World*, New York, N. Y.

Jones, F. W., Electrician, Bankers and Merchants Tel. Co., New York, N. Y.

Keith, N. S., Elec. Engr., New York, N. Y. (p. 820)

Leland, H. W., Mgr., Telephone Exchang
Jersey City, N. J.

Lockwood, Thomas D., Electrician, An
Bell Tel. Co., New York, N. Y.

Madden, O. E., Pres., Empire City Ele
Co., New York, N. Y.

Mailloux, C. O., Elec. Engr., New Yorl
N. Y. (p. 800)

Martin, T. Comerford, *The Electrical Worl*
New York, N. Y. (p. 789)

Maynard, Geo. C., Electrician, Washingto
D. C.

McKinistry, J. P., Cleveland, Ohio.

Morrison, J. Frank, Baltimore, Md.

Phelps, Geo. M., Elec. Engr. and Edito
New York, N. Y. (p. 821)

Plush, Dr. S. M., Electrician, Philadelphi
Pa.

Pope, Franklin L., Solicitor of Patent
New York, N. Y. (p. 788)

Rae, Frank B., Supt., Commercial Tel. Co
New York, N. Y. (p. 824)

Reilly, J. C., Supt., N. Y. & N. J. Tel. Co
Brooklyn, N. Y.

Roome, H. C., New York, N. Y.

Royce, Fred W., Electrician and Pater
Solicitor, Washington, D. C.

Sargent, W. D., Gen. Mgr., N. Y. & N.
Tel. Co., Brooklyn, N. Y.

Seely, J. A., Electrician, Metropolitan Te
and Tel. Co., New York, N. Y.

Slater, Henry B., Elec. Engr. and Electr
metallurgist, Leadville, Colo.

Smith, Gerritt, Circuit Electrician, Wester
Union Tel. Co., New York, N. Y.

Smith, J. Elliot, Supt., Fire Alarm Tel
graph, New York, N. Y.

Smith, Jesse M., Cons. Elec. Engr. an
Expert in Patent Cases, Detroit, Mich.

Sperry, E. A., Elec. Engr., Chicago, Ill. (
818)

Stockly, Geo. W., Vice-Pres. and Mgr
Brush Elec. Co., Cleveland, Ohio.

Thompson, Edward P., Cons. Electricia
and Patent Atty. in Elec. Cases, Ne
York, N. Y.

Thomson, Prof. Elihu, Electrician, Thomso
Houston E. Co., Lynn, Mass. (p. 79

Trowbridge, Prof. W. P., Columbia Colleg
New York, N. Y.

Vail, Theo. N., Pres., Metropolitan Te
and Tel. Co., New York, N. Y.

Vansize, William B., Solicitor of Patent
New York, N. Y.

Wallace, William, Wire Mfg., Ansoni
Conn.

Waring, Richard, Pittsburgh, Pa.

Weston, Edward, Electrician, United Stat
Elec. Lighting Co., New York, N.
(p. 789)

Wetzler, Joseph, Editor, "The Electric
World," New York, N. Y.

White, H. C., Mgr., Phoenix Iron Worl
Co., New York, N. Y.

Williams, Charles, Jr., Electrician, Bosto
Mass.

Worthington, Geo., *Electrical Review*, Ne
York.

Among Long-Standing Members

ALTHOUGH the American Institute of Electrical Engineers often is referred to by some of its most ardent supporters as an "organi-
ation of young men," and correctly so on the basis of membership
nalysis, here is a list of members that have been on the Institute's
olls for a total of some 35 to 50 years each, with an average tenure of
nembership for the 317 of them amounting to more than 40 years!
lthough the bulk of the burden of leadership and development may
all upon the younger members, the wealth of experience represented
n the professional careers of these and other long-time members of the
nstitute is one of the Institute's greatest assets.

1884 (7)

larke, Chas. L..Schenectady, N. Y.
ickerson, E. N...New York, N. Y.
amilton, Geo. A...Elizabeth, N. J.
illis, John........Cleveland, Ohio
ae, Frank B........Berkeley, Calif.
nomson, Elihu.........Lynn, Mass.
eston, Edward.......Newark, N. J.

1886 (4)

avis, M. M..North Chatham, Mass.
unter, R. M...... Philadelphia, Pa.
sull, Samuel..........Chicago, Ill.
urner, W. S..........Portland, Ore.

1887 (16)

hearn, Thomas..................
..........Ottawa, Ontario, Canada
ates, J. H. S........Olympia, Wash.
owell, J. W..........Newark, N. J.
owson, Hubert....New York, N. Y.
ckson, D. C.....Cambridge, Mass.
ichols, E. L............Ithaca, N. Y.
'Dea, M. T............Elmhurst, Ill.
orter, J. F........Kansas City, Mo.
ice, E. W., Jr...Schenectady, N. Y.
obinson, Almon......Lewiston, Me.
ohrer, A. L.......Maplewood, N. J.
yan, H. J.....Stanford Univ., Calif.
prague, F. J.......New York, N. Y.
erry, C. A.........New York, N. Y.
eeks, E. R.......Kansas City, Mo.
elles, F. R..........Altadena, Calif.

1888 (7)

oldmark, C. J...New Haven, Conn.
ennelly, A. E.....Cambridge, Mass.
ang, P. A.........London, England
esla, Nikola.......New York, N. Y.
ownsend, H. C....New York, N. Y.
addell, Montgomery..............
....................New York, N. Y.
ilson, Fremont....New York, N. Y.

1889 (15)

aylis, R. N........Bloomfield, N. J.
ogue, C. J..........Hoboken, N. J.
olby, E. A...........Newark, N. J.
avis, D. L.............Salem, Ohio
oane, S. E........New York, N. Y.
unlap, W. K...East Pittsburgh, Pa.
ayes, H. V...........Boston, Mass.
enshaw, F. V......New York, N. Y.
emp, Hermann....New York, N. Y.
osscrop, W. A...Hempstead, N. Y.
rsell, H. V. A.....New York, N. Y.
andall, J. E........Cleveland, Ohio
ebbins, Theodore..New York, N. Y.
hite, J. G.........New York, N. Y.
inslow, I. E...........Nice, France

1890 (20)

nnett, J. C........Montclair, N. J.
ack, C. N.....San Francisco, Calif.
ooks, Morgan......Urbana, Illinois
rnell, C. L..........Plainfield, N. J.
avis, C. H.........Cape Cod, Mass.
onner, W. H........Lansdowne, Pa.
mer, William.....Philadelphia, Pa.
tz, J. B......New Rochelle, N. Y.
eedman, W. H.......Nyack, N. Y.
tchinson, C. T...New York, N. Y.
e, J. C...........Wellesley, Mass.
ndell, Robert......Vreten, Sweden
arks, L. B........New York, N. Y.
pin, M. I........New York, N. Y.
ist, H. G.......Schenectady, N. Y.
senberg, E. M....Brooklyn, N. Y.
belacker, C. F....New York, N. Y.
aters, E. G.....Schenectady, N. Y.
hite, W. F........New York, N. Y.
hitmore, W. G..St. Petersburg, Fla

1891 (18)

Bedell, Frederick.......Ithaca, N. Y.
Bourne, Frank......London, England
Caldwell, Edward...New York, N. Y.
Dunn, Gano........New York, N. Y.
Gordon, Reginald...Newburgh, N. Y.
Hewlett, E. M....Schenectady, N. Y.
Land, Frank...........Nyack, N. Y.
Lovejoy, J. R.....Schenectady, N. Y.
Mordey, W. M.....London, England
Pattison, F. A......New York, N. Y.
Pike, C. W.........Philadelphia, Pa.
Rosebrugh, T. R..................
.........Toronto, Ontario, Canada
Simpson, A. B.......Brooklyn, N. Y.
Stone, C. A.........New York, N. Y.
Strong, F. G......Wethersfield, Conn.
Vanwyck, P. V. R..New York, N. Y.
Webster, E. S.........Boston, Mass.
Wilson, C. H..Mountain Lakes, N. J.

1892 (16)

Aldrich, W. S.........Syracuse, N. Y.
Arnold, B. J.............Chicago, Ill.
Cory, C. L...........Berkeley, Calif.
Crehore, A. C....E. Cleveland, Ohio
Edwards, J. P.......Cave Spring, Ga.
Gale, H. B............Natick, Mass.
Hunting, F. S......Fort Wayne, Ind.
Jackson, J. P.......New York, N. Y.
Meyer, Julius......New York, N. Y.
Page, A. D...........Clayton, N. J.
Ray, W. D.............Chicago, Ill.
Ross, R. A.........................
........Montreal, Quebec, Canada
Sachs, Joseph........Hartford, Conn.
Scott, C. F........New Haven, Conn.
Smith, F. S...........Allentown, Pa.
Stillwell, L. B........Princeton, N. J.

1893 (35)

Adams, A. D..........Boston, Mass.
Barbour, F. F.........Oakland, Calif.
Barnes, E. A.......Fort Wayne, Ind.
Boggs, L. S........E. Pittsburgh, Pa.
Brenner, W. H..........Atlanta, Ga.
Burke, James..............Erie, Pa.
Burnett, Douglas.....Baltimore, Md.
Burton, W. C........New York, N. Y.
Carpenter, C. E..................
.........Hopewell Junction, N. Y.
Comstock, L. K.....New York, N. Y.
Corey, F. B..........Barberton, Ohio
Corson, W. R. C.....Hartford, Conn.
Creaghead, T. J.......Covington, Ky.
Dodge, O. G.......Washington, D. C.
Dow, Alex.............Detroit, Mich.
Emmet, W. L. R..Schenectady, N. Y.
Ely, W. G........Schenectady, N. Y.
Fitzmaurice, J. S..Adelaide, Australia
Gerry, M. H., Jr...................
...............San Francisco, Calif.
Goldsborough, W. E..............
...................New York, N. Y.
Iwadare, Kunihiko.....Tokyo, Japan
Keller, E. E.........New York, N. Y.
Meredith, Wynn...................
...............San Francisco, Calif.
Moore, D. McF......Harrison, N. J.
Osborne, L. A.......New York, N. Y.
Puffer, W. L...........Boston, Mass.
Roper, D. W............Chicago, Ill.
Sands, H. S........Wheeling, W. Va.
Scheffler, F. A......New York, N. Y.
See, A. B...........New York, N. Y.
Storrs, H. A..........Oakland, Calif.
Wait, H. H..........Chesterton, Ind.
Waterman, F. N....New York, N. Y.
Worswick, A. E....London, England
Wray, J. G.............Chicago, Ill.

1894 (35)

Adams, C. A.......Cambridge, Mass.
Agnew, C. R........New York, N. Y.
Archbold, W. K......Syracuse, N. Y.
Barstow, W. S......New York, N. Y.
Berg, E. J........Schenectady, N. Y.
Berresford, A. W...New York, N. Y.
Billberg, C. O. C....Philadelphia, Pa.
Bliss, W. L......Niagara Falls, N. Y.
Boileau, W. E...........Bath, N. Y.
Caldwell, F. C.......Columbus, Ohio
Carichoff, E. R...Schenectady, N. Y.
Chesney, C. C.......Pittsfield, Mass.
Coho, H. B.........New York, N. Y.
Dommerque, F. J....Lakewood, N. J.
Dunn, K. G..........Berkeley, Calif.
Gossler, P. G.......New York, N. Y.
Hadaway, W. S., Jr...............
.............New Rochelle, N. Y.
Hadley, A. L.......Fort Wayne, Ind.
Hewitt, W. R.......New York, N. Y.
Hobart, H. M....Schenectady, N. Y.
Hubley, G. W.........Louisville, Ky.
Kirkland, J. W....................
..........Johannesburg, S. Africa
Knox, F. H.......Mt. Pleasant, S. C.
Lardner, H. A......New York, N. Y.
Moses, P. R........New York, N. Y.
Neiler, S. G.............Chicago, Ill.
Olivetti, Camillo.........Ivrea, Italy
Phillips, L. A.......New York, N. Y.
Price, C. W.........New York, N. Y.
Reed, H. D..........New York, N. Y.
Rouquette, W. F. B..Brooklyn, N. Y.
Sever, G. F..........Kingston, Mass.
Smith, F. E.....San Francisco, Calif.
Smith, J. B........Manchester, N. H.
Tait, F. M.............Dayton, Ohio

1895 (38)

Bancroft, C. F....St. Petersburg, Fla.
Berg, Eskil.......Schenectady, N. Y.
Boyer, E. E........East Lynn, Mass.
Buck, H. W........New York, N. Y.
Burton, P. G......Washington, D. C.
Cabot, F. E.......East Milton, Mass.
Coles, E. P..........Charlotte, N. C.
Coster, Maurice....New York, N. Y.
Crawford, D. F.......Pittsburgh, Pa.
Davis, W. J., Jr. ....
.................Schenectady, N. Y.
Degen, Lewis......Burlingame, Calif.
Fisher, H. W.....St. Petersburg, Fla.
Fortenbaugh, S. B.................
.................Schenectady, N. Y.
Garrels, W. L.........Kirkwood, Mo.
Gherardi, Bancroft..New York, N. Y.
Gherky, W. D.......Philadelphia, Pa.
Harvey, R. R.......Wilkes-Barre, Pa.
Hewitt, C. E.........Walpole, N. H.
Hubbard, A. S.........Bethel, Conn.
Klinck, J. H.......E. Pittsburgh, Pa.
Lincoln, P. M..........Ithaca, N. Y.
McMeen, S. G.......Pasadena, Calif.
Mershon, R. D......New York, N. Y.
Merz, C. H.........London, England
Nunn, P. N.....Salt Lake City, Utah
Parry, Evan........London, England
Pinkerton, Andrew....Pittsburgh, Pa.
Powell, P. H......Wallingford, Conn.
Price, E. F.........New York, N. Y.
Robinson, D. P......Philadelphia, Pa.
Roller, F. W........New York, N. Y.
Rushmore, D. B....New York, N. Y.
Storer, N. W.......E. Pittsburgh, Pa.
Swenson, B. V......New York, N. Y.
Torchio, Philip.....New York, N. Y.
Warren, A. K......New York, N. Y.
Webb, H. S............Scranton, Pa.
Wilcox, N. T...Melvin Village, N. H.

1896 (33)

Appleyard, A. E........Ashland, Wis.
Betts, Philander.......Newark, N. J.
Biddle, J. G.........Philadelphia, Pa.
Brinckerhoff, H. M...New York, N. Y
Chapman, A. W.....New York, N. Y.
Clark, C. M.........New York, N. Y.
Collett, S. D.........Brooklyn, N. Y.
Crain, J. J.........Waterbury, Conn.
Cunningham, E. R.....Portland, Ore.
Foster, S. L.....San Francisco, Calif.
Goddard, C. M........Boston, Mass.
Gorrissen, Charles.................
...............Hamburg, Germany
Greenleaf, L. S..........Troy, N. Y.
Griffes, E. V........Hollywood, Calif.
Hadley, F. W...........Atlanta, Ga.
Hammer, E. W.....New York, N. Y.
Hathaway, J. D....................
.........Montreal, Quebec, Canada
Hill, Nicholas, Jr....New York, N. Y.
Humphrey, H. H......St. Louis, Mo.
Iijima, Zentaro..........Tokyo, Japan
Little, C. W. G.....London, England
Maxwell, Eugene....Scottsbluff, Neb.
Moore, W. E.........Pittsburgh, Pa.
Porter, H. H........New York, N. Y.
Reid, E. S..........New York, N. Y.
Sampson, F. D.......Charlotte, N. C.
Schwabe, W. P..Thompsonville, Conn.
Speed, Buckner.....New York, N. Y.
Stewart, R. S.........La Jolla, Calif.
Straus, T. E..........Baltimore, Md.
Wagner, E. A........Pittsfield, Mass.
Whitaker, S. E......Bronxville, N. Y.
Wise, J. S., Jr........Allentown, Pa.

1897 (22)

Brackett, B. B......Vermillion, S. D.
Clement, E. E....Washington, D. C.
Copeland, C. A....Los Angeles, Calif.
Edmands, I. R......Brookline, Mass.
Frankenfield, Budd................
...............Los Angeles, Calif.
Hommel, Ludwig.....Pittsburgh, Pa.
Hopewell, C. F....Watertown, Mass.
Hosmer, Sidney.......Boston, Mass.
Jackson, W. B......New York, N. Y.
Kenan, W. R., Jr....New York, N. Y.
Kinsley, Carl.............Kearny, N. J.
Klauder, R. H......Philadelphia, Pa.
MacGregor, W. H.....Bayside, N. Y.
Mather, E. H...........Boston, Mass.
Mole, H. E............Summit, N. J.
Pillsbury, C. L...Minneapolis, Minn.
Rice, C. W..........New York, N. Y.
Richey, A. S........Worcester, Mass.
Scott, W. M........Philadelphia, Pa.
Shaw, H. B...........Raleigh, N. C.
Williams, Arthur....New York, N. Y.
Willis, E. J...........Richmond, Va.

1898 (27)

Allen, W. C......San Francisco, Calif.
Armstrong, A. H..Schenectady, N. Y.
Beebe, M. C.......Waterbury, Conn.
Carter, F. W.........Rugby, England
Crowell, Robinson....Oakland, Calif.
Damon, G. A.........Pasadena, Calif.
Dates, H. B..........Cleveland, Ohio
Davis, A. G.........New York, N. Y.
Doherty, H. L......New York, N. Y.
Downing, P. M.....................
...............San Francisco, Calif.
Gallatin, A. R......New York, N. Y.
Garfield, A. S.............Paris, France
Gaytes Herbert..San Francisco, Calif.
Gladson, W. N.....Fayetteville, Ark.
Hoffmann, Bernhard.New York ,N. Y.
James, H. D.......E. Pittsburgh, Pa.
Leitch, H. W.......New York, N. Y.
Livingston, J.......New York, N. Y.
Lohman, R. W....Los Angeles, Calif.
Muschenheim, F. A................
...................New York, N. Y.
Sharp, C. H.....White Plains, N. Y.
Thompson, J. W....................
...............Puebla Peu, Mexico
Tripier, Henri..........Paris, France
Vreeland, F. K.......New York, N. Y.
Wagner, H. A.........Baltimore, Md.
Winfield, J. H...Halifax, Nova Scotia
Woodbridge, J. E...................
...............San Francisco, Calif.

1899 (25)

Bogen, L. E........Milwaukee, Wis.
Burkett, C. W...San Francisco, Calif.
Chappell, W. E....Sheffield, England
Dyer, E. I...........Piedmont, Calif.
Edwards, C. V.....New York, N. Y.
Grant, L. T.....San Francisco, Calif.
Hallberg, J. H.....New York, N. Y.
Hardy, C. E.........Oakland, Calif.
Hewlett, E. F. J. H..................
...............Mansfield, England
Hill, E. R..........New York, N. Y.
Insull, M. J........... Chicago, Ill.
Lawrence, W. H....New York, N. Y.
Layman, W. A........ Chicago, Ill.
Lyford, O. S.........Bronxville, N. Y.
McCarter, R. D....New York, N. Y.
Moody, V. D...... New York, N. Y.
Peck, J. S......Manchester, England
Pendell, C. W...........Chicago, Ill.
Schweitzer, E. O.........Chicago, Ill
Scudder, H...... Schenectady, N. Y.
Skinner, C. E.......Wilkensburg, Pa.
Swope, G............New York, N. Y.
Wells, W. F.........Brooklyn, N. Y
Wilson, H. S........Brooklyn, N. Y.
Wolff, F. A.......Washington, D. C

Groups on Which the Institute Is Represented

Organizations	1903–04	1904–05	1905–06	1906–07	1907–08	1908–09	1909–10	1910–11	1911–12	1912–13	1913–14	1914–15	1915–16	1916–17	1917–18	1918–19	1919–20	1920–21	1921–22	1922–23	1923–24	1924–25	1925–26	1926–27	1927–28	1928–29	1929–30	1930–31	1931–32	1932–33
Nat'l Bureau of Eng'g Registration																														
Coörd. Comm. of Eng'g Societies																														⊕
International Edison Foundation																														⊕
Research Procedure Comm., Eng'g Foundation																													⊕	⊕
Engr's Coun. for Gen'l Devlpt.																													⊕	⊕
Electric St'ds Comm., A.S.A.																													⊕	⊕
Amer. Comm. Marking Obstructions to Air Navigation																													⊕	⊕
Eng'g Soc. Comm. Century of Progress Exp.																													⊕	⊕
Adv. Comm. on Aeronautic Radio Research																												⊕	⊕	⊕
Eng'g Societies Monographs Comm.																												⊕	⊕	⊕
Educ. Research Com., The Eng'g Foundation																												⊕	⊕	⊕
Hoover Medal Board of Award																											⊕	⊕	⊕	⊕
Alfred Noble Prize Comm.																											⊕	⊕	⊕	⊕
Eng'g Index Advisory Board																										⊕	⊕	⊕	⊕	⊕
Comm. on Heat Transmission, N.R.C.																										⊕	⊕	⊕	⊕	⊕
American Standards Ass'n																										⊕	⊕	⊕	⊕	⊕
Bd. Trustees Nat'l Museum Eng'g & Ind.																							⊕	⊕						
The Newcomen Society																							⊕	⊕	⊕	⊕				
Radio Adv. Comm., Bureau of St'ds																							⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕
Nat'l Safety Coun., A.S.S.E. Eng'g Sect.																							⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕
Gilbreth Int'l Comm. on Elim. Fatigue, S.I.E.																						⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	
American Marine Standards Comm.																						⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕
Soc. Pro. Eng'g Educ., Bd. Invest & Coörd.																					⊕	⊕	⊕	⊕	⊕	⊕	⊕			
Joint Conference Comm. of Founder Societies																					⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	
Nat'l Fire Waste Council																					⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕
Apparatus Maker & Users. Comm. of N.R.C.																					⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕
Chas. A. Coffin Fellowship & Research Fund Comm.																				⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕
Joint Comm. on Synch. Motors for Refrig. Mach.																				⊕	⊕	⊕								
U.S. Nat'l Comm. Int'l Electrotechnical Com.																			⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕
Joint Comm. on Welded Rail Joints																			⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕
American Eng'g Council Assembly																		⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕
Franco-American Eng'g Comm.																	⊕	⊕	⊕	⊕										
American Bureau of Welding																	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕
Spec. Joint Comm. Determination of Power Factor Polyphase																	⊕	⊕												
Joint Comm. on St'd Threads-Insulators & Pins																⊕	⊕													
Nat'l Research Coun., Eng'g & Indust. Research															⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕
Comm. Gen'l Eng'g Adv. Com. Coun. Nat'l Defense															⊕															
Joseph A. Holmes Safety Ass'n														⊕	⊕	⊕	⊕	⊕	⊕	⊕										
Commission of Washington Award														⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕
American Eng'g Standards Comm.														⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕					
Joint Comm. on Metric System														⊕																
Pan-American Eng'g Comm.														⊕	⊕	⊕														
Engineering Foundation Board													⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕
Joint Comm. on Eng'rs Officers Research Corps.													⊕	⊕																
Joint Comm. Classification Tech. Literature													⊕	⊕	⊕															
Naval Consulting Board													⊕	⊕	⊕	⊕	⊕	⊕												
Nat'l Joint Comm. Overh'd & Undergr'd Line Constr.												⊕	⊕	⊕	⊕	⊕	⊕	⊕												
American Comm. on Electrolysis											⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	
U.S. Nat'l Comm. of Int'l Illumination Com.											⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕
Joint Comm. on Legislation Relative Licensing Engrs.											⊕	⊕																		
Panama-Pacific Int'l Congress (1915) Bd. Managers											⊕	⊕																		
Nat'l Conservation Congress, Adv. Bd.											⊕	⊕	⊕																	
Library Board, United Eng'g Trustees Inc.										⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕
Amer. Elect. Railway Ass'n Joint Use of Poles										⊕	⊕	⊕	⊕																	
Joint Confer. Comm. of the Eng'g Soc.									⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕													
American Year Book Adv. Bd.									⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕					⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕
Resuscitation Commission									⊕	⊕																				
Nat'l Fire Protection Ass'n, Electr. Comm.								⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕
Gov't Adv. Bd. Fuels & Struct. Mats.							⊕																							
American Ass'n Adv. of Science Council						⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕
Joint Comm. on Eng'g Education					⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕												
United Eng'g Trustees Inc.			⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕
Joint Comm. Union Eng'g Bldg.	⊕	⊕	⊕	⊕																										
John Fritz Medal Board of Award	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕

THIS CHART shows the representation of the Institute on joint projects, since 1903, at which time joint participation was placed upon a more definite basis than previously existed. This chart is arranged to illustrate the expansion of interest in the later years.

The abbreviations used in the titles are as follows:

Adv.	Advisory
Bd.	Board
Com.	Commission
Comm.	Committee

In addition to these organizations on which the Institute has official representatives, there are of course a number of congresses and special commissions to which the Institute has sent delegates. These include the most important congresses held throughout the world since the organization of the Institute.

Note: The U.S. National Committee of the International Electrotechnical Commission Representatives, shown on this chart, is successor to the General committee which was dissolved in 1921, as shown on the chart of committees.

Chart of Institute Committees

Committee	Class	1887–88	1888–89	1889–90	1890–91	1891–92	1892–93	1893–94	1894–95	1895–96	1896–97	1897–98	1998–99	1899–00	1900–01	1901–02	1902–03	1903–04	1904–05	1905–06	1906–07	1907–08	1908–09	1909–10	1910–11	1911–12	1912–13	1913–14	1914–15	1915–16	1916–17	1917–18	1918–19	1919–20	1920–21	1921–22	1922–23	1923–24	1924–25	1925–26	1926–27	1927–28	1928–29	1929–30	1930–31	1931–32	1932–33	1933–34
ansfers	G	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	⊕	⊕
adare Foundation	G	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	⊕	⊕
onomic Status of the Engineer	G	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	⊕	⊕	⊕
pular Science Award	G	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	⊕	⊕	⊕	⊕
mme Medal	G	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	⊕	⊕	⊕	⊕	⊕	⊕
ectric Welding	T	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	⊕	⊕	⊕	⊕	⊕	⊕	⊕
tomatic Stations	T	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	⊕	⊕	⊕	⊕	⊕	⊕	⊕
lvisory Comm. to N. Y. Museum S. & I.	G	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	⊕	⊕	⊕	⊕	⊕	⊕	⊕
chnical Activities	S	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	⊕	⊕	·	·	·	·	·	·	·
gislation Affecting the Eng'g Profession	G	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕
lumbia University Scholarships	G	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕
vard of Institute Prizes	G	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕
esearch	T	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕
oördination of Institute Activities	G	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕
struments & Measurements	T	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕
ectrical Machinery	T	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕
eadquarters	G	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕
udent Branches	G	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕
velopment of Water Power	G	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	⊕	⊕	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
plications to Iron & Steel Production	T	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕
onomics of Electric Service	T	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	·	·	·	·	·	·	·	·	·	·	·	·	·
otective Devices	T	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕
plications to Marine Work	T	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕
plications to Mining Work	T	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕
tents	G	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	⊕	⊕	⊕	⊕	⊕	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
ganization of Technical Committees	S	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	⊕	⊕	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
nstitutional Revision	S	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	⊕	⊕	·	⊕	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
stitute Policy	G	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕
ectrophysics	T	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕
lations of Consulting Engineers	S	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	⊕	⊕	⊕	⊕	⊕	⊕	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
dexing Transactions	S	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	⊕	⊕	⊕	⊕	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
istorical Museum	S	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	⊕	⊕	⊕	⊕	⊕	⊕	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
ower Generation	T	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕
ectrochemistry & Electrometallurgy	T	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕
oduction & Application of Light	T	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕
eneral Power Applications	T	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕
lditional Grade of Membership	S	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	⊕	⊕	⊕	⊕	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
.S. Nat'l Com. Internat'l Electrotech. Comn.	G	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	·	(Succeeded by representatives)											
ansportation	T	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	·	⊕	·	·	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕
lucation	T	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕
ode of Principles of Professional Conduct	G	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	⊕	⊕	·	·	·	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕
bliography	S	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	⊕	⊕	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
nservation of Natural Resources	S	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	⊕	⊕	⊕	⊕	⊕	⊕	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
lison Medal	G	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	⊕	⊕	·	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕
onstitution & By-Laws	G	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	⊕	·	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	·	·	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕
ommunication	T	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	⊕	·	·	·	·	·	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕
ower Transmission & Distribution	T	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	⊕	⊕	·	·	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕
fety Codes	G	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕
ctions	G	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	⊕	⊕	·	·	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕
ilding Fund	S	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	⊕	⊕	·	⊕	⊕	⊕	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
w York Reception Comm.	S	·	·	·	·	·	·	·	·	·	·	·	·	·	⊕	⊕	⊕	⊕	·	·	·	·	·	·	·	·	⊕	⊕	⊕	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
andards	G	·	·	·	·	·	·	·	·	·	·	·	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕
öperative Research	G	·	·	·	·	·	·	·	·	·	·	·	⊕	⊕	⊕	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
ecutive	G	·	·	·	·	·	·	·	·	·	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕
nits & Standards	G	·	·	·	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
embership	G	·	·	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	·	·	·	⊕	⊕	·	·	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕
chnical Program	G	·	·	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕
brary	G	·	·	⊕	⊕	⊕	⊕	⊕	⊕	⊕	·	·	·	·	·	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·
blication	G	·	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	·	·	·	·	·	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕
nance	G	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	·	·	·	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕
ard of Examiners	G	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕

THIS CHART illustrates the growth of Institute activities as reflected by the number and diversity of committees. Only those committees acting for 2 years or more are shown. In every case the title is that by which it was last known, although it may have developed from another committee of different name but similar purpose.

The committees are designated as General, Technical, or Special by the letter in the first column following the title. Committees once known as "Standing" are classed as General, as are those of the earlier years when no differentiation was made.

Early Committees

Although the records of committee activities preceding 1887 are not complete, the following standing committees and their chairman appointed by the council of the Institute at its second meeting June 3, 1884, gives a very good idea of the recognized division of electrical engineering at that date:

Dynamo Electric Machines—Edward Weston
Telephones—Alexander Graham Bell
Telegraphs—George A. Hamilton
Arc Lamps—Edwin J. Houston
Incandescent Lamps—Thomas A. Edison
Prime Motor and Transmission of Power—Edward Weston
Electric Railways and Signals—Stephen D. Field
Underground and Submarine Cable Work—George A. Hamilton
Electrochemistry and Metallurgy—Nathaniel S. Keith
Voltaic Batteries, Galvanometers, and Measurements—Charles H. Haskins
Secondary Batteries—Edward J. Houston

In the first 4 volumes of the Institute's yearly TRANSACTIONS, references are made to various committees, most of which served only for a short time to meet some particular need. There was, of course, the committee on organization mentioned in the article "Formation of the Institute and the Enrolling of Its Charter Members" appearing on p. 822–4 of this issue.

Chairmen of the Institute's Committees

A CUMULATIVE listing of the chairmen of the Institute's general, technical, and special committees is given in the pages immediately following. These committees correspond with those shown in the charts on the preceding page. In the following listing, the dates of organization of the committees are given, together with the names and terms of service of all chairmen of these committees.

Executive Committee. Organized in 1896 to function as required between regular meetings of the board of directors.

Louis Duncan, Baltimore, Md............1896–97
F. B. Crocker, New York, N. Y...........1897–98
A. E. Kennelly, Philadelphia, Pa.........1898–00
Carl Hering, Philadelphia, Pa.............1900–01
C. P. Steinmetz, Schenectady, N. Y.......1901–02
C. F. Scott, Pittsburgh, Pa...............1902–03
B. J. Arnold, Chicago, Ill..................1903–04
J. W. Lieb, Jr., New York, N. Y..........1904–05
S. S. Wheeler, Ampere, N. J..............1905–06
Samuel Sheldon, Brooklyn, N. Y..........1906–07
H. G. Stott, New York, N. Y..............1907–08
L. A. Ferguson, Chicago, Ill..............1908–09
L. B. Stillwell, New York, N. Y...........1909–10
D. C. Jackson, Boston, Mass..............1910–11
Gano Dunn, New York, N. Y...............1911–12
R. D. Mershon, New York, N. Y..........1912–13
C. O. Mailloux, New York, N. Y..........1913–14
P. M. Lincoln, East Pittsburgh, Pa........1914–15
J. J. Carty, New York, N. Y...............1915–16
H. W. Buck, New York, N. Y..............1916–17
E. W. Rice, Jr., Schenectady, N. Y........1917–18
C. A. Adams, New York, N. Y.............1918–19
Calvert Townley, New York, N. Y.........1919–20
A. W. Berresford, Milwaukee, Wis........1920–21
William McClellan, Philadelphia, Pa......1921–22
F. B. Jewett, New York, N. Y.............1922–23
H. J. Ryan, Stanford Univ., Calif.........1923–24
Farley Osgood, Newark, N. J..............1924–25
M. I. Pupin, New York, N. Y..............1925–26
C. C. Chesney, Pittsfield, Mass...........1926–27
Bancroft Gherardi, New York, N. Y.......1927–28
R. F. Schuchardt, Chicago, Ill............1928–29
H. B. Smith, Worcester, Mass.............1929–30
W. S. Lee, New York, N. Y................1930–31
C. E. Skinner, East Pittsburgh, Pa........1931–32
H. P. Charlesworth, New York, N. Y......1932–33
J. B. Whitehead, Baltimore, Md...........1933–34

Board of Examiners. Organized in 1887 to study and recommend as to acceptability the qualifications of applicants for membership or applicants for transfer to a higher grade of membership.

W. B. Vansize, New York, N. Y..........1887–94
G. A. Hamilton, New York, N. Y.........1894–95
C. E. Emery, New York, N. Y.............1895–98
William Maver, Jr., New York, N. Y......1898–07
H. W. Buck, New York, N. Y..............1907–10
W. G. Carlton, New York, N. Y...........1910–12
H. St. Clair Putnam, New York, N. Y....1912–13
Maurice Coster, New York, N. Y..........1913–15
A. S. McAllister, New York, N. Y.........1915–18
F. L. Rhodes, New York, N. Y............1918–20
C. H. Sharp, New York, N. Y.............1920–21
H. H. Norris, Upper Montclair, N. J......1921–25
Erich Hausmann, Brooklyn, N. Y.........1925–27
E. H. Everit, New Haven, Conn..........1927–30
H. W. Drake, New York, N. Y............1930–31
H. Goodwin, Jr., Wyncotte, Pa...........1931–34

Coördination of Institute Activities, Committee on. Organized in 1920 to study and advise concerning matters affecting 2 or more committees or other subdivisions of the Institute's organization.

L. T. Robinson, Schenectady, N. Y........1920–21
W. I. Slichter, New York, N. Y...........1921–24
F. B. Jewett, New York, N. Y............1924–25
Farley Osgood, New York, N. Y..........1925–27
G. L. Knight, Brooklyn, N. Y............1927–28
H. A. Kidder, New York, N. Y...........1928–30
H. P. Charlesworth, New York, N. Y......1930–32
E. B. Meyer, Newark, N. J...............1932–34

Bibliography, Committee on. Organized in 1906; discontinued in 1908.

W. D. Weaver, New York, N. Y..........1906–08

Building Fund Committee. Organized in 1902 as the building committee; name changed in 1903 to the building fund committee; discontinued in 1908.

C. W. Rice, New York, N. Y.............1902–04
T. C. Martin, New York, N. Y............1905–08

Columbia University Scholarships, Committee on. Organized in 1923.

Francis Blossom, New York, N. Y........1923–25
W. I. Slichter, New York, N. Y...........1925–34

Conservation of Natural Resources, Committee on. Organized in 1905 as the committee on forest preservation; name changed in 1908 to the committee on conservation of natural resources; discontinued in 1911.

F. A. C. Perrine, New York, N. Y.........1905–07
C. H. Porter, Boston, Mass...............1907–08
H. G. Stott, New York, N. Y.............1908–10
L. B. Stillwell, New York, N. Y...........1910–11

Constitution and By-Laws Committee. Organized in 1903 as the committee on by-laws; reorganized in 1905 as the law committee; name changed in 1932 to the committee on constitution and by-laws.

R. W. Pope, New York, N. Y.............1903–04
C. O. Mailloux, New York, N. Y..........1905–08
H. G. Stott, New York, N. Y.............1908–11
Charles A. Terry, New York, N. Y........1911–14
G. H. Stockbridge, New York, N. Y.......1914–16
Samuel Sheldon, Brooklyn, N. Y..........1918–20
H. H. Barnes, Jr., New York, N. Y.......1920–24
L. F. Morehouse, New York, N. Y........1924–25
W. I. Slichter, New York, N. Y...........1925–27
C. O. Bickelhaupt, Atlanta, Ga...........1927–29
L. F. Morehouse, New York, N. Y........1929–30
E. B. Meyer, Newark, N. J................1930–31
W. S. Gorsuch, New York, N. Y..........1931–34

Constitutional Revision, Committee on. Organized in 1912; discontinued in 1916.

W. S. Murray, New Haven, Conn.........1912–13
Bancroft Gherardi, New York, N. Y.......1913–14
Bancroft Gherardi, New York, N. Y.......1915–16

Consulting Engineers, Committee on Relations of. Organized in 1910; discontinued in 1916.

Frank J. Sprague, New York, N. Y.......1910–11
Francis Blossom, New York, N. Y........1911–12
L. B. Stillwell, New York, N. Y...........1912–16

Economic Status of the Engineer, Committee on. Organized in 1931.

C. O. Bickelhaupt, New York, N. Y.......1931–34

Edison Medal Committee. Organized in 1905.

J. W. Howell, Harrison, N. J.............1905–0
C. L. Clarke, New York, N. Y............1908–1
Elihu Thomson, Swampscott, Mass.......1910–1
S. S. Wheeler, Ampere, N. J..............1913–1
A. E. Kennelly, Boston, Mass.............1916–1
Carl Hering, Philadelphia, Pa.............1917–2
C. A. Adams, Cambridge, Mass...........1920–2
E. D. Adams, New York, N. Y............1922–2
Gano Dunn, New York, N. Y..............1924–2
M. I. Pupin, New York, N. Y.............1927–2
Samuel Insull, Chicago, Ill................1928–3
D. C. Jackson, Cambridge, Mass..........1930–3
C. E. Stephens, New York, N. Y..........1933–3

Finance Committee. Organized in 1887 as th committee on permanent quarters; name subsequently changed to committee on finance, buildin and permanent quarters, 1889; and in 1896 t finance committee.

G. M. Phelps, New York, N. Y...........1887–9
F. B. Herzog, New York, N. Y............1895–9
W. B. Vansize, New York, N. Y..........1896–9
J. J. Carty, New York, N. Y..............1901–0
Calvert Townley, New Haven, Conn......1907–1
A. W. Berresford, Milwaukee, Wis........1910–1
C. W. Stone, Schenectady, N. Y..........1912–1
J. F. Stevens, Philadelphia, Pa............1913–1
N. A. Carle, Newark, N. J................1917–2
Charles Robbins, East Pittsburgh, Pa......1920–2
L. F. Morehouse, New York, N. Y........1921–2
G. L. Knight, Brooklyn, N. Y.............1923–2
H. A. Kidder, New York, N. Y............1926–2
E. B. Meyer, Newark, N. J................1928–3
C. E. Stephens, New York, N. Y..........1930–3
E. B. Meyer, Newark, N. J................1933–3

Headquarters Committee. Organized in 1917.

N. A. Carle, Newark, N. J................1917–2
W. A. Del Mar, Yonkers, N. Y...........1920–2
E. B. Craft, New York, N. Y.............1922–2
H. A. Kidder, New York, N. Y............1925–2
G. L. Knight, Brooklyn, N. Y.............1926–2
R. H. Tapscott, New York, N. Y.........1928–3
W. S. Gorsuch, New York, N. Y..........1933–3

Historical Museum Committee. Organized i 1910; discontinued in 1916.

T. C. Martin, New York, N. Y............1910–1

Indexing Transactions Committee. Organized i 1910; discontinued in 1914.

G. I. Rhodes, Boston, Mass...............1910–1

Institute Policy Committee. Organized in 191 as the public policy committee; name changed i 1933 to Institute policy.

J. J. Carty, New York, N. Y..............1911–1
Calvert Townley, New York, N. Y........1912–1
H. W. Buck, New York, N. Y.............1919–2
Gano Dunn, New York, N. Y..............1925–2
H. W. Buck, New York, N. Y.............1927–2
D. C. Jackson, Boston, Mass..............1928–3
Bancroft Gherardi, New York, N. Y.......1930–3
H. P. Charlesworth, New York, N. Y......1933–3

International Electrotechnical Commission, U.S national committee of the. Organized in 190 discontinued as a general committee in 192 functioning since under "Institute Representa tives."

Elihu Thomson, Lynn, Mass..............1907–0
A. E. Kennelly, Cambridge, Mass.........1909–1
C. O. Mailloux, New York, N. Y..........1911–1
F. B. Crocker, New York, N. Y...........1913–1
C. O. Mailloux, New York, N. Y..........1914–

Iwadare Foundation Committee. Organized in 1932.

F. B. Jewett, New York, N. Y. 1932–34

Lamme Medal Committee. Organized in 1928.

C. F. Scott, New Haven, Conn. 1928–31
C. C. Chesney, Pittsfield, Mass. 1931–32
C. E. Skinner, Wilkinsburg, Pa. 1932–34

Legislation Affecting the Engineering Profession, Committee on. Organized in 1924 as licensing of engineers committee; name changed in 1929 to committee on the engineering profession, and in 1931 to the committee on legislation affecting the engineering profession.

Francis Blossom, New York, N. Y. 1924–29
H. A. Kidder, New York, N. Y. 1929–33
W. I. Slichter, New York, N. Y. 1933–34

Library Committee. Organized in 1889; discontinued in 1916.

J. Stanford Brown, Yonkers, N. Y. 1889–96
W. D. Weaver, New York, N. Y. 1901–06
W. J. Jenks, New York, N. Y. 1906–07
Edward Caldwell, New York, N. Y. 1907–11
Samuel Sheldon, Brooklyn, N. Y. 1909–16

Membership Committee. Organized in 1889 as the committee on membership, etc.; reorganized in 1902 as the membership committee; again in 1906 as the committee on increase of membership; in 1909 became the membership committee.

R. W. Pope, New York, N. Y. 1889–99
W. S. Barstow, New York, N. Y. 1902–04
P. H. Thomas, New York, N. Y. 1906–07
D. B. Rushmore, Schenectady, N. Y. 1907–08
C. W. Stone, Schenectady, N. Y. 1908–09
A. W. Berresford, Milwaukee, Wis. 1909–10
Bancroft Gherardi, New York, N. Y. 1910–11
C. E. Scribner, New York, N. Y. 1911–12
H. C. Snook, Philadelphia, Pa. 1912–13
A. M. Schoen, Atlanta, Ga. 1913–14
H. D. James, East Pittsburgh, Pa. 1914–15
W. A. Hall, West Lynn, Mass. 1915–16
Harold Goodwin, Jr., Philadelphia, Pa. 1916–17
H. A. Pratt, New York, N. Y. 1917–19
R. W. Krass, New York, N. Y. 1919–20
E. H. Martindale, Cleveland, Ohio 1920–22
R. B. Howland, New York, N. Y. 1922–23
M. E. Skinner, Pittsburgh, Pa. 1923–24
E. E. Dorting, New York, N. Y. 1924–25
J. L. Woodress, St. Louis, Mo. 1925–26
L. S. O'Roark, New York, N. Y. 1926–27
E. B. Merriam, Schenectady, N. Y. 1927–28
J. E. Kearns, Chicago, Ill. 1928–29
J. Allen Johnson, Buffalo, N. Y. 1929–31
R. L. Kirk, Pittsburgh, Pa. 1931–33
E. S. Lee, Schenectady, N. Y. 1933–34

Membership Committee, Additional Grade of. Organized in 1908 as the intermediate grade of membership committee; name changed in 1911 to the additional grade of membership committee; discontinued in 1912.

C. F. Scott, Pittsburgh, Pa. 1908–10
C. W. Stone, Schenectady, N. Y. 1910–11
P. H. Thomas, New York, N. Y. 1911–12

New York Museum of Science and Industry, Advisory Committee to. Organized in 1927 as the advisory committee to the museums of the peaceful arts; changed in 1930 to the advisory committee to New York Museum of Science and Industry.

J. P. Jackson, New York, N. Y. 1927–34

New York Reception Committee. Organized 1900 as a subcommittee of papers and meetings; name changed in 1901 to the reception committee and in 1904 to the New York reception committee; inactive for several years; discontinued in 1915.

T. C. Martin, New York, N. Y. 1900–03
C. W. Rice, New York, N. Y. 1903–04
A. H. Lawton, New York, N. Y. 1912–14
F. C. Bates, New York, N. Y. 1914–15

Patent Committee. Organized in 1912; discontinued in 1917.

B. J. Arnold, Chicago, Ill. 1912–13
R. D. Mershon, New York, N. Y. 1913–17

Popular Science Award Committee. Organized in 1930.

A. E. Knowlton, New York, N. Y. 1930–31
F. W. Peek, Jr., Pittsfield, Mass. 1931–33
Harold Pender, Philadelphia, Pa. 1933–34

Prizes, Committee on Award of Institute. Organized in 1923.

L. W. W. Morrow, New York, N. Y. 1923–25
E. B. Meyer, Newark, N. J. 1925–27
H. P. Charlesworth, New York, N. Y. 1927–29
A. E. Knowlton, New York, N. Y. 1929–31
W. H. Harrison, New York, N. Y. 1931–33
R. N. Conwell, Newark, N. J. 1933–34

Professional Conduct Committee, Code of Principles of. Organized in 1906 as the code of ethics committee; name changed to code of principles of professional conduct committee, 1912.

S. S. Wheeler, Ampere, N. J. 1906–08
G. F. Sever, New York, N. Y. 1911–12
B. A. Behrend, Boston, Mass. 1912–13
G. F. Sever, New York, N. Y. 1913–21
C. A. Adams, Cambridge, Mass. 1921–22
S. S. Wheeler, Ampere, N. J. 1922–23
J. W. Lieb, New York, N. Y. 1923–28
H. B. Smith, Worcester, Mass. 1928–29
F. B. Jewett, New York, N. Y. 1929–31
R. F. Schuchardt, Chicago, Ill. 1931–33
C. E. Stephens, New York, N. Y. 1933–34

Publication Committee. Organized in 1888 as the editing committee; operated as a subcommittee of the meetings and papers committee, 1893–1901; reorganized as editing committee, 1901; name changed to publication committee, 1919.

G. A. Hamilton, Elizabeth, N. J. 1888–96
Gano Dunn, Ampere, N. J. 1901–03
C. T. Hutchinson, New York, N. Y. 1903–05
R. W. Pope, New York, N. Y. 1905–06
T. J. Johnston, New York, N. Y. 1906–07
G. F. Sever, New York, N. Y. 1907–10
A. F. Ganz, Hoboken, N. J. 1910–11
W. I. Slichter, New York, N. Y. 1911–12
L. T. Robinson, Schenectady, N. Y. 1912–14
H. H. Norris, New York, N. Y. 1914–16
W. I. Slichter, New York, N. Y. 1916–18
H. H. Norris, New York, N. Y. 1918–19
W. I. Slichter, New York, N. Y. 1919–20
N. A. Carle, Newark, N. J. 1920–21
A. S. McAllister, New York, N. Y. 1921–22
Donald McNicol, New York, N. Y. 1922–25
L. F. Morehouse, New York, N. Y. 1925–27
E. B. Meyer, Newark, N. J. 1927–28
W. S. Gorsuch, New York, N. Y. 1928–31
E. B. Meyer, Newark, N. J. 1931–34

Research, Committee on Coöperative. Organized in 1898; discontinued in 1901.

A. E. Kennelly, Philadelphia, Pa. 1898–01

Safety Codes Committee. Organized in 1902 as the National Electric Code committee; name changed in 1907 to the code committee; and to the safety codes committee, 1918.

A. E. Kennelly, Cambridge, Mass. 1902–05
F. B. Crocker, New York, N. Y. 1905–06
F. A. C. Perrine, New York, N. Y. 1906–08
C. W. Stone, Schenectady, N. Y. 1908–10
Farley Osgood, Newark, N. J. 1910–11
G. F. Sever, New York, N. Y. 1911–12
Farley Osgood, Newark, N. J. 1912–21
H. B. Gear, Chicago, Ill. 1921–24
Paul Spencer, Philadelphia, Pa. 1924–26
J. P. Jackson, New York, N. Y. 1926–28
F. V. Magalhaes, Philadelphia, Pa. 1928–29
A. W. Berresford, New York, N. Y. 1929–31
J. C. Forsyth, New York, N. Y. 1931–32
F. V. Magalhaes, Hopewell, N. J. 1932–33
F. V. Magalhaes, West Lynn, Mass. 1933–34

Sections Committee. Organized in 1902 as the local organizations committee; name changed to Sections committee, 1907.

C. W. Rice, New York, N. Y. 1902–03
C. F. Scott, Pittsburgh, Pa. 1903–04
C. F. Scott, Pittsburgh, Pa. ....March–Sept. 1906
Paul Spencer, Philadelphia, Pa. 1906–09
P. M. Lincoln, Pittsburgh, Pa. 1909–14
H. A. Horner, Philadelphia, Pa. 1914–16
W. A. Hall, West Lynn, Mass. 1916–20
J. B. Fisken, Spokane, Wash. 1920–21
A. W. Berresford, Milwaukee, Wis. 1921–24
H. B. Smith, Worcester, Mass. 1924–27
W. B. Kouwenhoven, Baltimore, Md. 1927–30
E. S. Lee, Schenectady, N. Y. 1930–33
I. Melville Stein, Philadelphia, Pa. 1933–34

Standards Committee. Organized in 1898 as the standardization committee; name changed to standards committee, 1907.

F. B. Crocker, New York, N. Y. 1898–02
H. J. Ryan, Ithaca, N. Y. 1902–04
C. F. Scott, Pittsburgh, Pa. ....April–Oct. 1905
F. B. Crocker, New York, N. Y. 1905–07
Samuel Sheldon, Brooklyn, N. Y. 1907–09
A. E. Kennelly, Cambridge, Mass. 1909–10
C. A. Adams, Cambridge, Mass. 1910–11
A. E. Kennelly, Cambridge, Mass. 1911–15
C. A. Adams, Cambridge, Mass. 1915–18
L. T. Robinson, Schenectady, N. Y. 1918–20
D. C. Jackson, Boston, Mass. 1920–21
Harold Pender, Philadelphia, Pa. 1921–23
H. S. Osborne, New York, N. Y. 1923–26
J. F. Meyer, Washington, D. C. 1926–28
F. D. Newbury, East Pittsburgh, Pa. 1928–31
A. M. MacCutcheon, Cleveland, Ohio 1931–34

Student Branches Committee. Organized in 1916 as a special committee; in 1917 as a subcommittee of the Sections committee; in 1919 became an independent committee.

C. W. Green, Boston, Mass. 1916–17
P. H. Daggett, Chapel Hill, N. C. 1917–18
C. F. Harding, Lafayette, Ind. 1918–23
C. E. Magnusson, Seattle, Wash. 1923–27
J. L. Beaver, Bethlehem, Pa. 1927–29
W. H. Timbie, Cambridge, Mass. 1929–33
L. A. Doggett, State College, Pa. 1933–34

Transfers Committee. Organized in 1932.

E. B. Meyer, Newark, N. J. 1932–33
J. Allen Johnson, Buffalo, N. Y. 1933–34

Technical Activities Committee. Organized in 1925; discontinued in 1927.

A. G. Pierce, Cleveland, Ohio 1925–27

Technical Committees, special committee on organization of. Organized in 1912; discontinued in 1914.

- H. G. Stott, New York, N. Y. ... 1912–13
- W. S. Rugg, New York, N. Y. ... 1913–14

Technical Program Committee. Organized in 1889 as the committee on papers and meetings; became a subcommittee of the committee on papers, meetings, and editing, 1893; name changed in 1895 to committee on papers and meetings; in 1901 to committee on papers; in 1907 to committee on meetings and papers; in 1932 to technical program committee.

- T. C. Martin, New York, N. Y. ... 1889–95
- F. B. Crocker, New York, N. Y. ... 1895–96
- H. L. Webb, New York, N. Y. ... 1896–00
- W. S. Barstow, New York, N. Y. ... 1900–01
- C. W. Rice, New York, N. Y. ... 1901–02
- Samuel Sheldon, Brooklyn, N. Y. ... 1902–06
- H. G. Stott, New York, N. Y. ... 1906–07
- P. H. Thomas, New York, N. Y. ... 1907–08
- A. H. Armstrong, Schenectady, N. Y. ... 1908–09
- H. St. Clair Putnam, New York, N. Y. ... 1909–10
- G. F. Sever, New York, N. Y. ... 1910–11
- H. W. Buck, New York, N. Y. ... 1911–12
- W. S. Rugg, New York, N. Y. ... 1912–14
- L. T. Robinson, Schenectady, N. Y. ... 1914–18
- W. I. Slichter, New York, N. Y. ... 1918–21
- E. E. F. Creighton, Schenectady, N. Y. ... 1921–23
- L. W. W. Morrow, New York, N. Y. ... 1923–25
- E. B. Meyer, Newark, N. J. ... 1925–27
- H. P. Charlesworth, New York, N. Y. ... 1927–29
- A. E. Knowlton, New York, N. Y. ... 1929–31
- W. H. Harrison, New York, N. Y. ... 1931–33
- R. N. Conwell, Newark, N. J. ... 1933–34

Units and Standards, Committee on. Organized in 1890; discontinued in 1901.

- A. E. Kennelly, Philadelphia, Pa., and Cambridge, Mass. ... 1890–01

Water Power, Committee on Development of. Organized in 1915; discontinued in 1917.

- Calvert Townley, New York, N. Y. ... 1915–16
- J. H. Finney, Washington, D. C. ... 1916–17

Technical Committees

Automatic Stations Committee. Organized in 1927.

- Chester Lichtenberg, Philadelphia, Pa. ... 1927–28
- W. H. Millan, St. Louis, Mo. ... 1928–29
- Ferdinand Zogbaum, New York, N. Y. ... 1929–31
- D. W. Taylor, Newark, N. J. ... 1931–34

Communication Committee. Organized in 1903 as the committee on telegraphy and telephony; name changed in 1924 to committee on communication.

- A. E. Kennelly, Cambridge, Mass. ... 1903–04
- K. B. Miller, Chicago, Ill. ... 1906–07
- William Maver, Jr., New York, N. Y. ... 1909–10
- Samuel Reber, New York, N. Y. ... 1910–11
- Bancroft Gherardi, New York, N. Y. ... 1911–12
- S. G. McMeen, Columbus, Ohio ... 1912–13
- F. F. Fowle, New York, N. Y. ... 1913–14
- C. E. Scribner, New York, N. Y. ... 1914–15
- G. M. Yorke, New York, N. Y. ... 1915–16
- F. L. Rhodes, New York, N. Y. ... 1916–17
- L. F. Morehouse, New York, N. Y. ... 1917–18
- Donald McNicol, New York, N. Y. ... 1918–22
- O. B. Blackwell, New York, N. Y. ... 1922–25
- H. P. Charlesworth, New York, N. Y. ... 1925–27
- H. W. Drake, New York, N. Y. ... 1927–29
- G. A. Kositzky, Cleveland, Ohio ... 1929–31
- H. S. Osborne, New York, N. Y. ... 1931–34

Education Committee. Organized in 1907 as a subcommittee of the meetings and papers committee; became an independent committee in 1909.

- H. H. Norris, Ithaca, N. Y. ... 1907–09
- D. C. Jackson, Boston, Mass. ... 1909–10
- A. S. Langsdorf, St. Louis, Mo. ... 1910–11
- J. P. Jackson, State College, Pa. ... 1911–12
- H. H. Norris, Ithaca, N. Y. ... 1912–14
- Vladimir Karapetoff, Ithaca, N. Y. ... 1914–16
- W. I. Slichter, New York, N. Y. ... 1916–17
- E. J. Berg, Schenectady, N. Y. ... 1917–18
- Vladimir Karapetoff, Ithaca, N. Y. ... 1918–19
- J. C. Parker, Ann Arbor, Mich. ... 1919–20
- C. E. Magnusson, Seattle, Wash. ... 1920–22
- W. E. Wickenden, New York, N. Y. ... 1922–24
- Harold Pender, Philadelphia, Pa. ... 1924–26
- P. M. Lincoln, Ithaca, N. Y. ... 1926–28
- Edward Bennett, Madison, Wis. ... 1928–30
- W. R. Work, Pittsburgh, Pa. ... 1930–31
- R. E. Doherty, New Haven, Conn. ... 1931–33
- L. A. Doggett, State College, Pa. ... 1933–34

Electric Welding Committee. Organized in 1927.

- J. C. Lincoln, Cleveland, Ohio ... 1927–28
- A. M. Candy, East Pittsburgh, Pa. ... 1928–30
- P. P. Alexander, West Lynn, Mass. ... 1930–32
- K. L. Hansen, Milwaukee, Wis. ... 1932–34

Electrical Machinery Committee. Organized in 1917.

- A. M. Gray, Ithaca, N. Y. ... 1917–19
- B. A. Behrend, Boston, Mass. ... 1919–23
- H. M. Hobart, Schenectady, N. Y. ... 1923–27
- F. D. Newbury, East Pittsburgh, Pa. ... 1927–28
- W. J. Foster, Schenectady, N. Y. ... 1928–29
- P. L. Alger, Schenectady, N. Y. ... 1929–32
- S. L. Henderson, East Pittsburgh, Pa. ... 1932–34

Instruments and Measurements Committee. Organized in 1917.

- S. G. Rhodes, New York, N. Y. ... 1917–20
- F. V. Magalhaes, New York, N. Y. ... 1920–22
- G. A. Sawin, East Pittsburgh, Pa. ... 1922–24
- A. E. Knowlton, New Haven, Conn. ... 1924–27
- E. S. Lee, Schenectady, N. Y. ... 1927–30
- E. J. Rutan, New York, N. Y. ... 1930–33
- W. B. Kouwenhoven, Baltimore, Md. ... 1933–34

Electrochemistry and Electrometallurgy Committee. Organized in 1910 as the electrochemical committee; name changed in 1916 to committee on electrochemistry and electrometallurgy.

- P. P. Barton, Niagara Falls, N. Y. ... 1910–11
- A. F. Ganz, Hoboken, N. J. ... 1911 16
- T. H. Schoepf, East Pittsburgh, Pa. ... 1916–17
- F. A. J. FitzGerald, Niagara Falls, N. Y. ... 1917–18
- Carl Hering, Philadelphia, Pa. ... 1918–19
- F. A. J. FitzGerald, Niagara Falls, N. Y. ... 1919–21
- Lawrence Addicks, New York, N. Y. ... 1921–22
- J. L. Yardley, East Pittsburgh, Pa. ... 1922–24
- G. W. Vinal, Washington, D. C. ... 1924–29
- P. H. Brace, East Pittsburgh, Pa. ... 1929–32
- W. C. Kalb, Cleveland, Ohio ... 1932–34

Electrophysics Committee. Organized in 1911.

- E. B. Rosa, Washington, D. C. ... 1911–12
- J. B. Whitehead, Baltimore, Md. ... 1912–16
- F. W. Peek, Jr., Pittsfield, Mass. ... 1916–17
- Frederick Bedell, Ithaca, N. Y. ... 1917–18
- F. W. Peek, Jr., Pittsfield, Mass. ... 1918–24
- J. H. Morecroft, New York, N. Y. ... 1924–26
- Vladimir Karapetoff, Ithaca, N. Y. ... 1926–29
- O. E. Buckley, New York, N. Y. ... 1929–31
- Vannevar Bush, Cambridge, Mass. ... 1931–33
- Joseph Slepian, East Pittsburgh, Pa. ... 1933–34

Iron and Steel Production, Committee on Applications to. Organized in 1914 as the committee on iron and steel industry; name changed in 1924 to the committee on (electrical) applications to iron and steel production.

- J. C. Reed, Steelton, Pa. ... 1914–15
- T. E. Tynes, Buffalo, N. Y. ... 1915–16
- Wilfred Sykes, East Liberty, Pa. ... 1916–17
- F. D. Egan, Midland, Pa. ... 1917–18
- Eugene Friedlaender, Braddock, Pa. ... 1918–19
- W. F. James, Philadelphia, Pa. ... 1919–21
- E. S. Jefferies, Hamilton, Ont., Can. ... 1921–23
- F. B. Crosby, Worcester, Mass. ... 1923–26
- A. G. Pierce, Cleveland, Ohio ... 1926–28
- M. M. Fowler, Chicago, Ill. ... 1928–30
- A. C. Cummins, Duquesne, Pa. ... 1930–32
- F. O. Schnure, Sparrows Point, Md. ... 1932–34

Light, Committee on Production and Application of. Organized in 1909 as the electric lightning committee; name subsequently was changed to electrical illumination committee (1913), electric lighting committee (1914), lighting and illumination committee (1916), and in 1924 to committee on production and application of light.

- W. L. Robb, Troy, N. Y. ... 1909–10
- Peter Junkersfeld, Chicago, Ill. ... 1910–12
- W. C. L. Eglin, Philadelphia, Pa. ... 1912–13
- C. H. Sharp, New York, N. Y. ... 1913–16
- E. P. Hyde, Cleveland, Ohio ... 1916–18
- C. E. Clewell, Philadelphia, Pa. ... 1918–21
- G. H. Stickney, Harrison, N. J. ... 1921–25
- P. S. Millar, New York, N. Y. ... 1925–28
- B. E. Schackelford, Bloomfield, N. J. ... 1928–29
- G. S. Merrill, Cleveland, Ohio ... 1929–31
- W. T. Blackwell, Newark, N. J. ... 1931–33
- J. W. Barker, New York, N. Y. ... 1933–34

Marine Work, Committee on Applications to. Organized in 1913 as the committee on use of electricity in marine work; name subsequently changed to marine committee (1916), and then to committee on applications to marine work (1924).

- C. S. McDowell, New York, N. Y. ... 1913–16
- H. A. Hornor, Philadelphia, Pa. ... 1916–19
- Arthur Parker, Camden, N. J. ... 1919–22
- G. A. Pierce, Philadelphia, Pa. ... 1922–24
- L. C. Brooks, Wollaston, Mass. ... 1924–26
- G. A. Pierce, Philadelphia, Pa. ... 1926–27
- W. E. Thau, New York, N. Y. ... 1927–30
- R. A. Beekman, Schenectady, N. Y. ... 1930–33
- H. C. Coleman, East Pittsburgh, Pa. ... 1933–34

Mining Work, Applications to. Organized in 1912 as the committee on the use of electricity in mines; name subsequently changed to committee on mines (1919), and later (1924) to committee on applications to mining work.

- G. R. Wood, Philadelphia, Pa. ... 1912–13
- Wilfred Sykes, East Liberty, Pa. ... 1913–16
- H. H. Clark, Pittsburgh, Pa. ... 1916–17
- K. A. Pauly, Schenectady, N. Y. ... 1917–19
- W. A. Chandler, Scottsdale, Pa. ... 1919–20
- Graham Bright, East Pittsburgh, Pa. ... 1920–23
- F. L. Stone, Schenectady, N. Y. ... 1923–26
- W. H. Lesser, Frackville, Pa. ... 1926–28
- Carl Lee, Chicago, Ill. ... 1928–31
- D. E. Renshaw, East Pittsburgh, Pa. ... 1931–33
- E. B. Wagner, Wilkes-Barre, Pa. ... 1933–34

Power Applications, Committee on General. Organized in 1908 as the committee on industrial power; name subsequently changed to industrial power committee (1909), committee on industrial and domestic power (1916), committee on general power applications (1924).

- D. B. Rushmore, Schenectady, N. Y. ... 1908–10
- N. T. Wilcox, Lowell, Mass. ... 1910–11
- W. H. Powell, Milwaukee, Wis. ... 1911–12
- J. M. Hipple, East Pittsburgh, Pa. ... 1912–13
- Rudolph Tschentscher, South Chicago, Ill. ... 1913–14

D. B. Rushmore, Schenectady, N. Y.	1914–16
E. H. Martindale, Cleveland, Ohio	1916–18
A. G. Pierce, Pittsburgh, Pa.	1918–21
W. C. Yates, Schenectady, N. Y.	1921–22
H. D. James, East Pittsburgh, Pa.	1922–24
A. E. Waller, Bronxville, N. Y.	1924–25
A. M. MacCutcheon, Cleveland, Ohio	1925–28
J. F. Gaskill, Philadelphia, Pa.	1928–30
C. W. Drake, East Pittsburgh, Pa.	1931–33
M. R. Woodward, Chicago, Ill.	1933–34

Protective Devices Committee. Organized in 1913 as a subcommittee of the electric power committee; subsequently became the protective apparatus committee (1914), and then protective devices committee (1916).

C. P. Steinmetz, Schenectady, N. Y.	1913–14
E. E. F. Creighton, Schenectady, N. Y.	1914–16
D. W. Roper, Chicago, Ill.	1916–21
H. R. Woodrow, Brooklyn, N. Y.	1921–25
E. C. Stone, Pittsburgh, Pa.	1925–26
F. L. Hunt, Greenfield, Mass.	1926–28
E. A. Hester, Pittsburgh, Pa.	1928–30
Raymond Bailey, Philadelphia, Pa.	1930–32
R. T. Henry, Buffalo, N. Y.	1932–34

Power Generation Committee. Organized in 1910 as the power station committee; subsequently changed to prime movers committee (1913), power station committee (1914), and then to power generation committee (1924).

H. S. Putnam, New York, N. Y.	1910–11
S. D. Sprong, New York, N. Y.	1911–12
H. G. Stott, New York, N. Y.	1912–15
A. S. Loizeaux, Baltimore, Md.	1915–16
J. G. De Remer, New York, N. Y.	1916–17
Philip Torchio, New York, N. Y.	1917–20
H. P. Liversidge, Philadelphia, Pa.	1920–21
Nicholas Stahl, Providence, R. I.	1922–24
V. E. Alden, Baltimore, Md.	1924–26
W. S. Gorsuch, New York, N. Y.	1926–28
F. A. Allner, Baltimore, Md.	1928–31
J. R. Baker, Baltimore, Md.	1931–33
H. W. Leitch, New York, N. Y.	1933–34

Power Transmission and Distribution Committee. Organized in 1902 as a subcommittee of the meetings and papers committee; became the high tension transmission committee (1909), a subcommittee of the electric power committee (1913); in 1914 again became independent as the transmission committee; in 1916 became transmission and distribution committee; in 1924 became committee on power transmission and distribution.

R. D. Mershon, New York, N. Y.	1902–04
R. D. Mershon, New York, N. Y.	1906–10
P. H. Thomas, New York, N. Y.	1910–11
D. B. Rushmore, Schenectady, N. Y.	1911–12
P. H. Thomas, New York, N. Y.	1912–13
P. W. Sothman, New York, N. Y.	1913–14
P. H. Thomas, New York, N. Y.	1914–16
L. E. Imlay, Niagara Falls, N. Y.	1916–18
E. B. Meyer, Newark, N. J.	1918–23
F. G. Baum, San Francisco, Calif.	1923–24
P. H. Thomas, New York, N. Y.	1924–26
Philip Torchio, New York, N. Y.	1926–28
H. R. Woodrow, Brooklyn, N. Y.	1928–30
P. H. Chase, Philadelphia, Pa.	1930–33
D. M. Simmons, New York, N. Y.	1933–34

Research Committee. Organized in 1921 as a general standing committee; became one of the group of technical committees in 1923.

F. B. Jewett, New York, N. Y.	1921–22
J. B. Whitehead, Baltimore, Md.	1922–27
F. W. Peek, Jr., Pittsfield, Mass.	1927–29
S. M. Kintner, East Pittsburgh, Pa.	1929–30
L. W. Chubb, East Pittsburgh, Pa.	1930–32
C. W. Rice, Schenectady, N. Y.	1932–33
F. M. Farmer, New York, N. Y.	1933–34

Transportation Committee. Organized in 1907 as the railway subcommittee of the meetings and papers committee; became an independent committee on railways in 1909; traction and transportation committee in 1916; and committee on transportation, 1924.

A. H. Armstrong, Schenectady, N. Y.	1907–08
B. J. Arnold, Chicago, Ill.	1908–09
William McClellan, New York, N. Y.	1909–10
F. J. Sprague, New York, N. Y.	1910–14
D. C. Jackson, Boston, Mass.	1914–16
N. W. Storer, East Pittsburgh, Pa.	1916–18
C. F. Uebelacker, New York, N. Y.	1918–19
W. S. Murray, New York, N. Y.	1919–20
C. S. Ruffner, New York, N. Y.	1920–21
H. M. Brinckerhoff, New York, N. Y.	1921–22
N. W. Storer, East Pittsburgh, Pa.	1923–24
J. V. B. Duer, Altoona, Pa.	1926–28
W. M. Vandersluis, Chicago, Ill.	1928–29
Sidney Withington, New Haven, Conn.	1929–31
E. L. Moreland, Boston, Mass.	1931–34

Economics of Electric Service, Committee on. Organized in 1913 as the committee on records and appraisals of properties, this committee changed its name in 1916 to committee on economics of electric service; was discontinued in 1921.

W. B. Jackson, Chicago, Ill.	1913–15
Philander Betts, Newark, N. J.	1915–17
W. B. Jackson, Chicago, Ill.	1917–19
C. S. Ruffner, New York, N. Y.	1919–20
Philip Torchio, New York, N. Y.	1920–21

Chairmen of the Institute's Sections

A LIST of the 61 Sections of the Institute, together with the date of authorization of the Section, and the names and terms of service of all chairmen of these Sections are given below.

AKRON

Authorized August 12, 1920

H. C. Stephens	1920–22
S. C. Henton	1922–23
P. C. Jones	1923–24
J. T. Walther	1924–25
R. Higgins	1925–26
A. R. Holden	1926–27
A. L. Richmond	1927–28
J. Grotzinger	1928–29
W. A. Hillebrand	1929–30
H. C. Paiste	1930–31
R. R. Krammes	1931–32
A. P. Regal	1932–33
P. C. Smith	1933–34

ATLANTA

Authorized January 14, 1904

A. M. Schoen	1904–07
J. H. Finney	1907–08
W. R. Collier	1908–09
H. P. Wood	1909–11
A. M. Schoen	1911–20
H. L. Wills	1920–21
J. E. Mellett	1921–22
G. K. Selden	1922–23
C. L. Emerson	1923–24
W. R. Collier	1924–25
W. E. Gathright	1925–26
C. E. Bennett	1926–27
T. H. Landgraf	1927–28
H. L. Wills	1928–30
H. C. Uhl	1930–31
A. G. Stanford	1931–32
O. O. Rae	1932–33
D. H. Woodward	1933–34

BALTIMORE

Authorized December 16, 1904

J. B. Whitehead	1904–21
D. Burnett	1921–22
W. B. Kouwenhoven	1922–31
K. A. Hawley	1931–32
J. Wells	1932–33
L. G. Smith	1933–34

BIRMINGHAM

Authorized May 2, 1929

W. E. Bare	1929–30
	1930–31
	1931–32
	1932–33
W. W. Ballew	1933–34

BOSTON

Authorized February 13, 1903

C. L. Edgar	1903–04
R. Fleming	1904–05
C. A. Adams	1905–06
H. E. Clifford	1906–07
Wm. L. Puffer	1907–08
A. E. Kennelly	1908–09
D. C. Jackson	1909–10
J. F. Vaughan	1910–11
Wm. L. Hooper	1911–12
F. P. Valentine	1912–13
J. N. Neall	1913–14
G. W. Palmer, Jr.	1914–15
L. L. Elden	1915–16
G. A. Burnham	1916–17
H. M. Hope	1917–18
I. M. Cushing	1918–19
I. E. Moultrop	1919–20
W. I. Middleton	1920–21
L. W. Abbott	1921–22
E. L. Moreland	1922–23
A. Macomber	1923–24
F. S. Dellenbaugh	1924–25
J. W. Kidder	1925–26
Hartley Rowe	1926–27
E. W. Davis	1927–28
H. B. Dwight	1928–29
W. H. Colburn	1929–30
J. P. Kobrock	1930–31
C. A. Corney	1931–32
F. D. Hallock	1932–33
W. H. Timbie	1933–34

CHICAGO

Authorized 1893

	1893
G. A. Damon	1902–04
K. B. Miller	1904–06
H. R. King	1906–08
W. L. Abbott	1908–10
J. G. Wray	1910–12
R. H. Rice	1912–13
D. W. Roper	1913–14
E. W. Allen	1914–15
W. J. Norton	1915–16
T. Milton	1916–17
Wm. J. Crumpton	1917–18
C. A. Keller	1918–19
A. F. Riggs	1919–20
J. R. Bibbins	1920–21
M. M. Fowler	1921–22
F. E. Goodnow	1922–23
J. E. Kearns	1923–24
G. H. Jones	1924–25
Carl Lee	1925–26
K. A. Auty	1926–27
B. E. Ward	1927–28
P. B. Juhnke	1928–29
T. G. LeClair	1929–30
F. H. Lane	1930–31
F. R. Innes	1931–32
L. R. Mapes	1932–33
E. C. Williams	1933–34

CINCINNATI

Authorized June 30, 1920

J. D. Lyon	1920–22
A. M. Wilson	1922–24
O. Shepard	1924–25
H. C. Blackwell	1925–26
W. P. Beattie	1926–27
R. C. Fryer	1927–29
T. C. Reed	1929–31
E. S. Fields	1931–32
L. O. Dorfman	1932–33
L. C Nowland	1933–34

CLEVELAND

Authorized September 27, 1907

H. B. Dates	1907–08
C. W. Ricker	1908–09
H. L. Wallau	1909–10
A. M. Allen	1910–11
B. A. Stowe	1911–12
E. J. Edwards	1912–13
J. C. Lincoln	1913–14
H. Dingle	1914–15
E. H. Martindale	1915–16
E. W. P. Smith	1916–17
C. N. Rakestraw	1917–18
C. S. Ripley	1918–19
B. W. David	1919–20
A. M. MacCutcheon	1920–21
I. H. Van Horn	1921–22
L. D. Bale	1922–23
G. B. Schneeberger	1923–24
C. P. Cooper	1924–25
C. L. Dows	1925–26
H. L. Grant	1926–27
A. M. Lloyd	1927–28
E. W. Henderson	1928–29
T. D. Owens	1929–30
F. W. Braund	1930–31
G. A. Kositzky	1931–32
J. M. Smith	1932–33
R. C. Putnam	1933–34

COLUMBUS

Authorized March 17, 1922

F. C. Caldwell	1922–23
E. M. Fitz	1923–24
F. R. Price	1924–25
R. J. B. Feather	1925–26
A. W. Janowitz	1926–27
F. C. Nesbitt	1927–28
W. E. Metzger	1928–29
R. A. Brown	1929–30
C. D. Price	1930–31
W. L. Everitt	1931–32
K. Y. Tang	1932–33
A. G. Gibbony	1933–34

CONNECTICUT

Authorized April 16, 1921

C. F. Scott..........1921–22
E. H. Everit..........1922–24
Wm. A. Moore.......1924–25
A. A. Packard........1925–26
A. E. Knowlton.......1926–28
E. J. Amberg........1928–29
S. Withington........1929–30
S. Ferguson..........1930–31
R. G. Warner........1931–32
C. J. Daly...........1932–33
C. T. Hughes........1933–34

DALLAS

Authorized May 18, 1928

G. A. Mills..........1928–29
J. B. Thomas........1929–30
L. T. Blaisdell.......1930–31
G. A. Dyer..........1931–32
H. K. Handley.......1932–33
D. H. Levy..........1933–34

DENVER

Authorized May 18, 1915

W. A. Carter.........1915–16
H. S. Sands..........1916–17
Norman Read........1917–18
F. J. Rankin.........1918–19
H. S. Evans..........1919–20
D. C. McClure.......1920–21
B. C. J. Wheatlake...1921–22
H. B. Barnes.........1922–23
H. B. Dwight.........1923–24
W. C. DuVall........1924–25
V. L. Board..........1925–26
W. H. Edmunds......1926–27
A. L. Jones..........1927–28
L. N. McClellan......1928–29
W. H. Bullock........1929–30
R. B. Bonney........1930–31
R. E. Nyswander.....1931–32
W. D. Hardaway.....1932–33
A. W. Ainsworth.....1933–34

DETROIT ANN-ARBOR

Authorized January 13, 1911

C. L. deMuralt.......1911–12
J. J. Woolfenden.....1912–13
A. R. Sawyer........1913–14
H. H. Norton........1914–15
R. Collamore........1915–16
A. A. Meyer.........1916–17
H. H. Higbie.........1917–18
G. E. Lewis..........1918–19
J. C. Parker.........1919–20
C. Kittredge.........1920–21
A. S. Albright........1921–22
J. H. Cannon........1922–23
E. L. Bailey.........1923–24
F. L. Snyder.........1924–25
G. B. McCabe.......1925–26
Harold Cole..........1926–27
F. H. Riddle.........1927–28
A. H. Lovell.........1928–29
L. F. Hickernell......1929–30
L. Braisted..........1930–31
J. J. Shoemaker......1931–32
O. E. Hauser.........1932–33
R. Foulkrod.........1933–34

ERIE

Authorized January 11, 1918

C. P. Yoder..........1918–19
J. C. Barry..........1919–20
M. C. Goodspeed.....1920–21
A. H. Schum.........1921–22
W. J. Seibert.........1922–23
M. W. Metzner.......1923–24
B. L. Delack.........1924–25
H. J. Hansen.........1925–26
F. A. Tennant.......1926–27
L. H. Curtis..........1927–28
M. L. Elder..........1928–29
W. H. Pelton........1929–30
J. R. McDonald......1930–31
P. R. Urich..........1931–32
J. C. Milling.........1932–33
W. D. Bearce........1933–34

FLORIDA

Authorized January 28, 1931

Joseph Weil..........1931–34

FORT WAYNE

Authorized August 14, 1908

E. A. Wagner........1908–12
T. W. Behan.........1912–14
L. D. Nordstrum.....1914–15
J. J. Kline...........1915–18
P. C. Morganthaler...1918–19
C. I. Hall............1919–20
E. L. Simpson........1920–21
R. H. Chadwick......1921–22
S. W. Greenland......1922–23
C. C. Grandy........1923–24
A. B. Campbell......1924–25
E. L. Gaines.........1925–26
D. W. Merchant.....1926–27
P. O. Noble..........1927–28
C. F. Beyer..........1928–29
F. W. Merrill........1929–30
W. J. Morrill.........1930–31
E. J. Schaefer.......1931–32
B. A. Case...........1932–33
C. M. Summers......1933–34

HOUSTON

Authorized August 7, 1928

C. A. Williamson.....1928–29
L. K. Del'Homme....1929–30
C. D. Farman........1930–31
E. M. Wise...........1931–32
J. B. Arthur.........1932–33
J. S. Waters.........1933–34

INDIANAPOLIS-LAFAYETTE

Authorized January 12, 1912

O. S. More..........1912–14
J. L. Wayne.........1914–17
H. O. Garman.......1917–18
G. B. Schley.........1918–19
J. L. Wayne.........1919–22
D. C. Pyke..........1922–24
W. A. Black.........1924–25
H. M. Anthony......1925–26
J. B. Bailey..........1926–27
C. A. Fay............1927–28
H. Kessel............1928–29
J. B. Bailey..........1929–30
E. G. Ralston........1930–31
E. L. Carter.........1931–32
E. G. Thoms.........1932–33
C. E. Chatfield.......1933–34

IOWA

Authorized June 25, 1929

C. L. Sampson.......1929–30
J. K. McNeely.......1930–31
H. B. Hoffhaus......1931–32
L. F. Wood..........1932–33
E. R. McKee........1933–34

ITHACA

Authorized October 15, 1902

Harris J. Ryan.......1902–06
E. L. Nichols.........1906–16
F. Bedell............1916–18
A. Gray.............1918–20
J. G. Pertsch.........1920–26
R. F. Chamberlain....1926–29
W. C. Ballard, Jr.....1929–31
W. E. Meserve.......1931–33
B. K. Northrop......1933–34

KANSAS CITY

Authorized April 14, 1916

A. A. Thompson......1916–17
W. F. Barnes........1917–20
G. C. Shaad.........1920–23
R. L. Weber.........1923–24
D. D. Clarke.........1924–25
F. S. Dewey.........1925–26
R. L. Baldwin........1926–27
S. M. DeCamp.......1927–28
B. J. George.........1928–29
A. B. Covey.........1929–30
J. S. Palmer.........1930–31
G. Fiske.............1931–32
G. O. Brown.........1932–33
R. W. Warner........1933–34

LEHIGH VALLEY

Authorized April 16, 1921

C. Hodge............1921–22
D. M. Petty.........1922–23
H. G. Hervey........1923–24
J. L. Beaver.........1924–25
W. H. Lesser.........1925–26
W. E. Lloyd, Jr.......1926–27
M. R. Woodward.....1927–28
H. D. Baldwin.......1928–29
A. J. Althouse........1929–30
W. M. Harbaugh......1930–31
Morland King.........1931–32
J. G. Charest........1932–33
N. S. Hibshman.....1933–34

LOS ANGELES

Authorized May 19, 1908

C. W. Koiner........1908–09
J. A. Lighthipe.......1909–10
J. E. MacDonald.....1910–11
O. H. Ensign.........1911–12
G. A. Damon........1912–13
E. R. Northmore.....1913–14
C. G. Pyle...........1914–15
E. Woodbury.........1915–16
R. H. Manahan.....1916–17
D. Morgan.........1917–18
J. H. Cunningham....1918–19
C. A. Copeland......1919–20
R. W. Sorensen......1920–21
H. H. Cox...........1921–22
J. N. Kelman.........1922–23
E. R. Stauffacher.....1923–24
C. A. Heinze.........1924–25
R. A. Hopkins.......1925–26
R. E. Cunningham...1926–27
L. C. Williams.......1927–28
H. L. Caldwell.......1928–29
N. B. Hinson.........1929–30
H. W. Hitchcock.....1930–31
P. S. Biegler.........1931–32
F. E. Dellinger.......1932–33
A. P. Hill............1933–34

LOUISVILLE

Authorized October 15, 1926

D. C. Jackson, Jr.....1926–28
E. D. Wood..........1928–29
H. W. Wischmeyer...1929–30
James Clark, Jr.......1930–31
P. P. Ash............1931–32
C. M. Ewing.........1932–33
S. T. Fife............1933–34

LYNN

Authorized August 22, 1911

E. E. Boyer..........1911–12
W. A. Hall...........1912–13
E. R. Berry..........1913–14
W. H. Pratt.........1914–15
G. N. Chamberlin....1915–16
G. Campbell.........1916–17
J. M. Davis..........1917–18
L. E. Underwood.....1918–19
A. K. Warren........1919–20
L. C. Loewenstein....1920–21
F. J. Rudd..........1921–22
J. W. West..........1922–23
L. E. Smith.........1923–24
B. W. St. Clair.......1924–25
E. D. Dickinson......1925–26
D. F. Smalley........1926–27
W. F. Dawson.......1927–28
C. Skoglund.........1928–29
I. F. Kinnard........1929–30
A. L. Ellis...........1930–31
J. A. Cook..........1931–32
W. K. Dickinson.....1932–33
S. A. Moss...........1933–34

MADISON

Authorized January 8, 1909

M. H. Collbohm......1909–11
J. N. Cadby..........1911–12
E. H. Kifer..........1912–13
E. Bennett..........1913–14
J. W. Shuster........1914–15
M. C. Beebe.........1915–16
F. A. Kartak.........1916–17
J. R. Price...........1917–18
J. W. Watson........1918–19
C. M. Jansky........1919–20
G. C. Neff...........1920–21
C. B. Hayden........1921–22
H. M. Crothers......1922–23
G. E. Wagner........1923–24
R. G. Walter.........1924–25
L. E. A. Kelso.......1925–26
E. J. Kallevang......1926–27
J. T. Rood...........1927–28
L. J. Peters..........1928–29
R. E. Purucker.......1929–30
L. C. Larson.........1930–31
N. H. Blume.........1931–32
G. F. Tracy..........1932–33
T. A. Brown.........1933–34

MEMPHIS

Authorized May 23, 1930

M. Eldredge.........1930–31
W. A. Gentry........1931–32
G. O. MacFarlane....1932–33
F. L. Christenbury...1933–34

MEXICO

Authorized June 29, 1922

......................1922–23
D. K. Lewis.........1923–25
E. F. Lopez..........1925–26
Carlos Macias........1926–27
B. Nikiforoff.........1927–28
P. M. McCullough....1928–29
G. Solis Payan.......1929–30
B. E. Arias..........1930–31
E. F. Lopez..........1931–32
W. A. Schulenburg...1932–33
C. E. Plumb.........1933–34

MILWAUKEE

Authorized February 11, 1910

W. H. Powell........1910–11
F. A. Vaughan.......1911–12
T. E. Barnum........1912–13
L. E. Bogen.........1913–14
L. L. Tatum.........1914–15
R. B. Williamson.....1915–16
F. W. Ells...........1916–17
A. Simon............1917–18
F. A. Coffin..........1918–19
H. P. Reed...........1919–20
H. W. Cheney........1920–21
F. J. Mayer..........1921–22
G. C. Post...........1922–23
S. H. Mortensen......1923–24
C. T. Evans.........1924–25
H. R. Huntley.......1925–26
H. L. Van Valkenberg.1926–27
J. D. Ball...........1927–28
E. R. Stoekle........1928–29
E. W. Seeger.........1929–30
F. A. Kartak.........1930–31
C. H. Krueger........1931–32
W. F. Lent..........1932–33
K. L. Hansen........1933–34

MINNESOTA

Authorized April 7, 1902

G. D. Shepardson....1902–05
E. P. Burch..........1905–06
H. J. Gille...........1906–07
E. H. Scofield........1907–09
J. C. Vincent........1909–11
C. L. Pillsbury.......1911–12
A. L. Abbott.........1912–13
W. T. Ryan..........1913–14
L. H. Cooper........1914–15
E. T. Street..........1915–16
R. J. S. Carter.......1916–17
F. W. Springer.......1917–18
M. Barnert..........1918–19
F. Dustin............1919–20
J. D. Marshall.......1920–21
W. T. Ryan.........1921–22
F. A. Otto...........1922–23
H. W. Meyer........1923–24
E. H. Scofield........1924–25
A. G. Dewars........1925–26
S. B. Hood..........1926–27
J. E. Sumpter........1927–28
M. E. Todd.........1928–29
V. E. Engquist.......1929–30
D. K. Lewis.........1930–31
O. Gaarden..........1931–32
H. J. Pierce.........1932–33
E. H. Hagensick......1933–34

MONTANA

Authorized June 24, 1931

J. A. Thaler.........1931–34

NEBRASKA

Authorized January 21, 1925

P. M. McCullough....1925–26
C. W. Minard........1926–27
N. W. Kingsley......1927–28
C. D. Robison.......1928–29
D. H. Braymer.......1929–30
W. O. Jacobi.........1930–31
A. L. Turner........1931–32
C. Talsma...........1932–33
H. S. Pahren.........1933–34

NEW ORLEANS

Authorized December 8, 1933

James M. Todd......1933–34

NEW YORK

Authorized December 10, 1919

H. W. Buck.........1919–21
Farley Osgood.......1921–22
Calvert Townley.....1922–23
L. F. Morehouse.....1923–24
H. H. Barnes, Jr.....1924–25
H. A. Kidder........1925–26
E. B. Meyer.........1926–27
L. W. W. Morrow....1927–28
R. H. Tapscott.......1928–29
H. P. Charlesworth...1929–30
J. B. Bassett........1930–31
O. H. Caldwell.......1931–32
T. F. Barton.........1932–33
C. R. Jones..........1933–34

NIAGARA FRONTIER

Authorized February 10, 1925

J. Allen Johnson......1925–26
H. B. Alverson.......1926–27
L. E. Imlay..........1927–28
G. H. Calkins........1928–29
R. T. Henry.........1929–30
E. S. Bundy.........1930–31
R. W. Graham.......1931–32
F. S. Wahl...........1932–33
J. S. Henderson......1933–34

NORTH CAROLINA

Authorized March 21, 1929

E. P. Coles..........1929–30
J. H. Paget..........1930–31
J. E. Lear...........1931–32
F. L. Moser.........1932–33
H. M. Doerschuk.....1933–34

OKLAHOMA CITY

Authorized February 16, 1922

F. W. Insull.........1922–23
T. M. Fariss.........1923–25
E. R. Page..........1925–27
E. Kurtz............1927–28
C. V. Bullen.........1928–29
C. W. Mier..........1929–30
F. J. Meyer.........1930–31
C. T. Almquist.......1931–32
E. B. Jennings.......1932–33
R. F. Danner........1933–34

PHILADELPHIA

Authorized February 18, 1903

Carl Hering..........1902–03
C. E. Hewitt.........1903–04
H. A. Foster.........1904–05
C. W. Pike...........1905–06
W. C. L. Eglin.......1906–07
J. F. Stevens.........1907–08
Paul Spencer.........1908–09
G. A. Hoadley........1909–10
C. I. Young..........1910–11
H. C. Snook..........1911–12
H. A. Hornor.........1912–13
A. R. Cheyney........1913–14
H. S. Sanville........1914–15
J. H. Tracy..........1915–16
H. P. Liversidge......1916–17
N. Hayward..........1917–18
W. F. James.........1918–19
C. E. Clewell.........1919–20
C. E. Bonine.........1920–21
P. H. Chase..........1921–22
E. B. Tuttle..........1922–23
R. B. Mateer.........1923–24
C. D. Fawcett........1924–25
N. Shute.............1925–26
L. J. Costa...........1926–27
I. M. Stein...........1927–28
L. F. Deming.........1928–29
R. H. Silbert.........1929–30
D. H. Kelly..........1930–31
C. N. Johnson........1931–32
Lewis Fussell.........1932–33
P. S. Harkins.........1933–34

PITTSBURGH

Authorized October 13, 1902

P. M. Lincoln........1902–04
N. W. Storer.........1904–05
S. P. Grace..........1905–06
H. W. Fisher.........1906–07
C. E. Skinner........1907–08
W. E. Reed..........1908–09
C. B. Auel...........1909–10
H. N. Muller.........1910–11
K. C. Randall........1911–12
E. L. Farrar..........1912–13
A. M. Dudley........1913–14
J. W. Welsh..........1914–15
T. H. Schoepf........1915–16
G. C. Hecker.........1916–17
F. E. Wynne.........1917–18
W. R. Work..........1918–19
J. G. Carroll..........1919–20
B. C. Dennison.......1920–21
H. W. Smith..........1921–22
E. C. Stone..........1922–23
O. Needham..........1923–24
M. E. Skinner........1924–25
G. S. Humphrey......1925–26
D. M. Simmons.......1926–27
W. C. Goodwin.......1927–28
H. E. Dyche..........1928–29
J. A. Cadwallader....1929–30
C. T. Sinclair........1930–31
F. A. Conner.........1931–32
T. Spooner...........1932–33
R. L. Kirk...........1933–34

PITTSFIELD

Authorized March 25, 1904

F. A. C. Perrine......1904–05
C. C. Chesney........1905–06
G. Wright............1906–07
J. Insull.............1907–08
W. A. Hall...........1908–09
H. W. Tobey.........1909–10
S. H. Blake..........1910–11
G. Faccioli...........1911–12
W. C. Smith..........1912–13
J. J. Frank...........1913–14
W. W. Lewis.........1914–15
M. O. Troy...........1915–16
V. E. Goodwin........1916–17
F. F. Brand..........1917–18
N. Currie............1918–19
R. E. Wagner.........1919–20
F. W. Peek, Jr........1920–21
I. H. Sclater.........1921–22
W. P. White..........1922–23
E. D. Treanor........1923–24
N. F. Hanley.........1924–25
E. D. Eby...........1925–26
E. F. Gehrkens.......1926–27
H. O. Stephens.......1927–28
J. R. Rue............1928–29
L. F. Blume..........1929–30
C. H. Kline..........1930–31
F. R. Finch..........1931–32
V. M. Montsinger.....1932–33
W. H. Cooney........1933–34

PORTLAND

Authorized May 18, 1909

O. B. Coldwell.......1909–11
F. D. Weber..........1911–12
H. R. Wakeman.......1912–13
G. P. Nock..........1913–14
R. F. Monges.........1914–15
P. Lebenbaum........1915–16
L. T. Merwin.........1916–17
E. D. Searing.........1917–18
R. M. Boykin.........1918–19
E. F. Whitney........1919–21
W. C. Heston.........1921–22
D. W. Proebstel......1922–23
E. F. Pearson.........1923–24
H. P. Cramer.........1924–25
L. W. Ross...........1925–26
J. C. Henkle.........1926–27
J. E. Yates...........1927–28
L. M. Moyer.........1928–29
H. H. Cake...........1929–30
A. H. Kreul..........1930–31
R. J. Davidson.......1931–32
F. M. Lewis.........1932–33
V. B. Wilfley.........1933–34

PROVIDENCE

Authorized March 12, 1920

W. C. Slade..........1920–21
N. Stahl.............1921–22
R. W. Adams.........1922–23
H. A. Stanley.........1923–24
W. B. Lewis.........1924–25
W. P. Field..........1925–26
E. E. Nelson.........1926–27
F. N. Tompkins.......1927–28
A. E. Watson.........1928–29
F. W. Smith..........1929–30
J. W. Young.........1930–31
W. S. Maddocks......1931–32
I. W. Knight.........1932–33
O. W. Briden.........1933–34

ROCHESTER

Authorized October 9, 1914

J. C. Parker.........1914–15
E. L. Wilder.........1915–16
O. W. Bodler.........1916–17
F. C. Taylor.........1917–18
R. H. Manson........1918–19
J. W. Morrison.......1919–20
H. J. Schiefer........1920–21
S. Alling.............1921–22
G. A. Scoville........1922–23
W. S. Burch..........1923–24
F. T. Bryne..........1924–25
A. E. Soderholm......1925–26
E. C. Karker.........1926–27
R. D. DeWolf.........1927–28
H. E. Gordon.........1928–29
V. M. Graham........1929–30
H. J. Klumb..........1930–31
F. C. Young..........1931–32
C. F. Estwick.........1932–33
E. G. Eidam..........1933–34

ST. LOUIS

Authorized January 14, 1903

W. E. Goldsborough...1903–04
H. H. Humphrey.....1904–05
A. H. Timmerman.....1905–06
A. S. Langsdorf......1906–10
G. W. Lamke.........1910–12
J. A. Osborn.........1912–13
F. J. Bullivant.......1913–14
S. N. Clarkson.......1914–15
W. O. Pennell........1915–16
A. McR. Harrelson...1916–17
H. W. Eales.........1917–18
J. L. Hamilton........1918–19
G. A. Waters.........1919–21
J. L. Woodress.......1921–22
J. M. Chandlee.......1922–24
B. D. Hull...........1924–25
F. D. Lyon..........1925–26
W. H. Millan.........1926–27
L. F. Woolston.......1927–28
C. P. Potter..........1928–29
G. H. Quermann......1929–30
C. B. Fall............1930–31
C. H. Kraft...........1931–32
F. B. Wipperman.....1932–33
L. S. Washington.....1933–34

SAN ANTONIO

Authorized May 23, 1930

D. W. Flowers........1930–31
J. E. Woods.........1931–32
I. A. Uhr............1932–33
V. H. Braunig........1933–34

SAN FRANCISCO

Authorized December 23, 1904

G. O. Squier.........1904–05
C. L. Cory...........1905–07
A. M. Hunt..........1907–08
C. W. Burkett........1908–09
G. R. Murphy........1909–10
S. J. Lisberger........1910–11
S. B. Charters........1911–12
H. W. Crozier........1912–13
A. H. Griswold.......1913–14
C. J. Wilson.........1914–15
A. H. Babcock.......1915–16
J. E. Woodbridge.....1916–17
L. R. Jorgensen......1917–18
J. C. Clark..........1918–19
W. G. Vincent........1919–20
J. P. Jollyman........1920–21
W. P. L'Hommedieu..1921–22
H. H. Henline........1922–23
J. A. Koontz, Jr......1923–24
F. R. George.........1924–25
R. C. Powell.........1925–26
D. I. Cone...........1926–27
W. L. Winter.........1927–28
B. D. Dexter.........1928–29
L. F. Fuller..........1929–30
P. B. Garrett.........1930–31
E. A. Crellin.........1931–32
E. F. Maryatt........1932–33
W. C. Smith.........1933–34

SASKATCHEWAN

Authorized October 14, 1925

E. W. Bull...........1925–26
S. R. Parker.........1926–27
J. D. Peters..........1927–28
E. W. Bull...........1928–29
J. R. Crowley........1929–30
W. T. Hunt..........1930–31
N. W. Dubois........1931–33
H. Forbes Roberts....1933–34

SCHENECTADY

Authorized January 26, 1903

C. P. Steinmetz.......1903–05
D. B. Rushmore......1905–08
E. J. Berg...........1908–09
M. O. Troy..........1909–10
E. A. Baldwin........1910–11
E. B. Merriam.......1911–12
J. B. Taylor.........1912–13
G. H. Hill...........1913–14
H. M. Hobart........1914–15
L. T. Robinson.......1915–16
C. E. Eveleth........1916–17
W. L. Upson.........1917–18
K. A. Pauly.........1918–19
C. S. Van Dyke......1919–20
H. R. Summerhayes..1920–21
S. H. Blake..........1921–22
C. M. Davis.........1922–23
R. C. Muir..........1923–24
J. R. Craighead......1924–25
W. J. Davis, Jr.......1925–26
R. E. Doherty.......1926–27
T. A. Worcester......1927–28
E. S. Lee...........1928–29
R. Treat............1929–30
E. S. Henningsen.....1930–31
R. A. Beekman.......1931–32
E. E. Johnson........1932–33
D. W. McLenegan ...1933–34

SEATTLE

Authorized January 19, 1904

K. G. Dunn.........1904–05
Howard Joslyn........1905–06
C. E. Magnusson......1906–08
J. H. Harisberger.....1908–10
A. A. Miller.........1910–12
J. D. Ross...........1912–13
S. C. Lindsay........1913–15
C. E. Magnusson......1915–17
J. Harisberger........1917–19
G. E. Quinan........1919–21
J. P. Growden........1921–22
C. F. Terrell.........1922–23
C. A. Lund..........1923–24
J. Hellenthal.........1924–25
E. A. Loew..........1925–26
C. E. Mong..........1926–27
C. R. Wallis.........1927–29
L. N. Robinson.......1929–30
C. E. Carey..........1930–31
M. T. Crawford.......1931–32
A. F. Darland........1932–33
G. L. Hoard.........1933–34

SHARON

Authorized December 11, 1925

W. M. Dann.........1925–26
H. L. Cole...........1926–27
L. H. Hill............1927–28
H. B. West..........1928–29
J. B. Gibbs..........1929–30
S. S. Cook..........1930–31
R. M. Field..........1931–32
A. P. Bender.........1932–33
W. W. Satterlee......1933–34

SOUTHERN VIRGINIA

Authorized May 19, 1922

.....................1922–23
Wm. C. Bell..........1923–24
H. B. Hawkins.......1924–25
W. S. Rodman.......1925–28
H. C. Leonard.......1928–30
J. H. Berry..........1930–32
Cecil Gray...........1932–33
E. L. Lockwood......1933–34

SPOKANE

Authorized February 14, 1913

J. B. Fisken..........1913–14
J. W. Hungate........1914–15
V. H. Greisser........1915–16
D. F. Henderson.....1916–17
C. A. Lund..........1917–18
G. Nixon............1918–19
J. E. E. Royer.......1919–20
R. S. Daniels........1920–21
L. J. Pospisil........1921–22
H. L. Melvin.........1922–23
E. R. Hannibal.......1923–24
J. S. McNair.........1924–25
G. S. Covey.........1925–26
R. McKay...........1926–27
L. R. Gamble........1927–28
B. Olsen............1928–29
E. Baughn..........1929–30
L. A. Traub.........1930–31
H. L. Vincent........1931–32
C. F. Norberg........1932–33
W. M. Allen.........1933–34

SPRINGFIELD

Authorized June 29, 1922

W. A. Dick..........1922–23
J. M. Newton........1923–24
G. W. Atkinson......1924–25
R. P. King..........1925–26
L. F. Curtis..........1926–27
C. A. M. Weber......1927–28
J. F. Murray........1928–29
F. L. Hunt..........1929–30
J. N. Alberti........1930–31
B. V. K. French......1931–32
Hans Passburg.......1932–33
L. C. Packer.........1933–34

SYRACUSE

Authorized August 12, 1920

E. T. Moore.........1920–22
R. D. Whitney.......1922–24
W. C. Pearce........1924–26
C. E. Dorr...........1926–28
W. R. McCann.......1928–29
F. E. Verdin.........1929–31
C. W. Henderson.....1931–33
W. E. Mueller.......1933–34

TOLEDO

Authorized June 3, 1907

W. G. Nagel.........1907–08
C. R. McKay........1908–09
M. W. Hansen.......1909–11
G. E. Kirk..........1911–16
W. E. Richards.......1916–17
W. A. Hill...........1917–21
G. Southern.........1921–24
P. R. Knapp.........1924–25
A. H. Stebbins.......1925–26
O. F. Rabbe.........1926–27
T. J. Nolan..........1927–28
W. T. Lowery........1928–29
E. B. Featherstone...1929–30
F. H. Dubs..........1930–31
J. A. Dinwiddie......1931–32
I. H. Heitkamp......1932–33
E. H. Howell........1933–34

TORONTO

Authorized September 30, 1903

J. A. Kammerer......1903–04
T. R. Rosebrugh.....1904–05
H. A. Moore,
R. T. MacKeen....1905–06
R. G. Black..........1906–07
K. L. Aitken.........1907–08
W. A. Bucke.........1908–09
H. W. Price..........1909–10
E. Richards..........1910–11
A. L. Mudge.........1911–12
F. A. Gaby..........1912–13
H. D. McDougall.....1913–16
E. T. J. Brandon.....1916–17
W. G. Gordon........1917–18
A. H. Hull...........1918–19
A. B. Cooper.........1919–20
F. R. Ewart.........1920–21
W. P. Dobson........1921–22
S. E. M. Henderson...1922–23
C. E. Schwenger......1923–24
H. C. Don Carlos.....1924–25
L. B. Chubbuck......1925–26
M. B. Hastings.......1926–27
C. E. Sisson.........1927–28
E. M. Wood.........1928–29
F. F. Ambuhl........1929–30
D. A. McKenzie......1930–31
T. W. Eadie.........1931–32
I. M. Maclean.......1932–33
G. D. Floyd.........1933–34

URBANA

Authorized November 25, 1902

W. H. Williams......1902–06
J. M. Bryant........1906–08
E. B. Paine.........1908–09
C. T. Knipp.........1909–10
Morgan Brooks......1910–11
E. H. Waldo 1911–12
A. M. Buck..........1912–13
Morgan Brooks......1913–14
I. W. Fisk...........1914–15
P. S. Biegler.........1915–16
I. W. Fisk 1916–17
L. V. James.........1917–18
A. R. Knight........1918–19
Morgan Brooks......1919–21
E. H. Waldo.........1921–22
H. A. Brown.........1922–23
E. B. Paine.........1923–24
C. T. Knipp.........1924–25
C. A. Keener.........1925–26
J. T. Tykociner......1926–27
J. O. Kraehenbuehl...1927–28
J. K. Tuthill.........1928–29
M. A. Faucett.......1929–30
C. E. Skroder........1930–31
E. H. Waldo.........1931–32
E. A. Reid...........1932–33
H. N. Hayward......1933–34

UTAH

Authorized March 9, 1917

A. S. Peters..........1917–19
M. Cheever..........1919–20
J. F. Merrill.........1920–21
P. P. Ashworth.......1921–22
C. C. Pratt..........1922–23
C R. Higson.........1923–24
H. W. Clark.........1924–25
J. Salberg............1925–26
B. C. J. Wheatlake...1926–27
D. L. Brundige.......1927–28
C. B. Shipp..........1928–29
A. C. Kelm..........1929–30
L. B. Fuller..........1930–31
Paul Ransom........1931–32
A. L. Taylor.........1932–33
H. T. Plumb.........1933–34

VANCOUVER

Authorized August 22, 1911

F. D. Nims..........1911–13
E. M. Breed..........1913–14
E. P. LaBelle........1914–15
R. F. Hayward.......1915–20
F. Sawford...........1920–21
J. R. Read...........1921–22
T. H. Crosby........1922–23
F. W. MacNeill......1923–24
C. N. Beebe.........1924–25
A. Vilstrup..........1925–26
R. L. Hall...........1926–27
A. C. R. Yuill........1927–28
C. W. Colvin........1928–29
J. Teasdale..........1929–30
H. Vickers...........1930–31
G. R. Wright........1931–33
L. B. Stacey.........1933–34

WASHINGTON

Authorized April 9, 1903

F. A. Wolff..........1903–04
Samuel Reber........1904–05
E. B. Rosa...........1905–06
Edgar Russel........1906–07
P. G. Burton.........1907–08
P. Betts.............1908–10
E. Wheeler..........1910–12
J. H. Finney.........1912–13
H. C. Eddy..........1913–14
C. B. Mirick.........1914–15
R. H. Dalgleish......1915–16
A. Dunlop...........1916–17
P. G. Agnew.........1917–18
J. E. Smith...........1918–19
M. M. Flanders......1919–21
A. R. Cheyney.......1921–22
L. T. Blaisdell.......1922–23
L. M. Evans.........1923–24
J. H. Ferry..........1924–25
A. F. E. Horn........1925–26
C. A. Robinson.......1926–27
M. G. Lloyd..........1927–28
L. D. Bliss...........1928–29
W. A. E. Doying.....1929–30
G. W. Vinal.........1930–31
G. L. Weller.........1931–32
T. J. MacKavanagh..1932–33
R. Whitehurst.......1933–34

WORCESTER

Authorized February 18, 1920

C. R. Oliver.........1920–21
G. M. Hardy........1921–22
F. J. Adams.........1922–23
L. E. Pierce..........1923–24
S. M. Anson.........1924–25
E. T. Harrop.........1925–26
C. F. Hood..........1926–27
G. F. Woodward.....1927–28
A. F. Snow..........1928–29
H. H. Newell........1929–30
J. K. Oldham........1930–31
J. P. McCann........1931–32
H. A. Maxfield.......1932–33
L. S. Leavitt.........1933–34

Past and Present Officers of the Institute

*Abbott, Arthur V., *V-P.*, 1900–02.
Adams, Comfort A., *M.*, 1912–15; *V-P.*, 1915–17; *P.*, 1918–19.
Adsit, C. G., *V-P.*, 1921–23.
*Anthony, Wm. A., *V-P.*, 1886–89; *P.*, 1890–91; *V-P.*, 1894–6.
Armstrong, A. H., *M.*, 1903–06; *V-P.*, 1906–08.
Arnold, Bion J., *M.*, 1895–98; *V-P.*, 1902–03; *P.*, 1903–04.
Auty, K. A., *V-P.*, 1932– .

Babcock, A. H., *V-P.*, 1918–19.
Barnes, H. H., Jr., *M.*, 1910–13; *V-P.*, 1913–15.
Barstow, W. S., *M.*, 1900–03; *V-P.*, 1903–05.
†Bates, D. H., *V-P.*, 1885–87.
*Baum, Frank G., *V-P.*, 1906–08.
Beaver, J. L., *V-P.*, 1927–29.
Bedell, Frederick, *M.*, 1914–17; *V-P.*, 1917–18.
*Behrend, B. A., *M.*, 1913–16; *V-P.*, 1916–18.
*Bell, Alexander G., *V-P.*, 1884–85; *P.*, 1891–92.
*Bell, Louis, *M.*, 1891–94.
Bennett, Edward, *V-P.*, 1924–26.
Berresford, A. W., *M.*, 1909–12; *V-P.*, 1912–14; *P.*, 1920–21.
Bettis, A. E., *V-P.*, 1926–28; *D.*, 1928–32.
Bickelhaupt, C. O., *V-P.*, 1927–29.
†Black, R. G., *M.*, 1910–13.
Bonney, R. B., *V-P.*, 1933– .
*Brackett, Cyrus F., *M.*, 1886–89.
*Bradley, Chas. S., *M.*, 1894–97; *V-P.*, 1897–99; *M.*, 1899–1902.
*Brooks, David, M., *M.*, 1885–88.
Brooks, Morgan, *M.*, 1907–10; *V-P.*, 1910–12.
*Brush, Chas. F., *M.*, 1884–87.
Bryant, J. M., *M.*, 1924–28.
Buck, Harold W., *M.*, 1907–10; *V-P.*, 1910–12; *P.*, 1916–17.
*Buckingham, Chas. L., *M.*, 1885–88.
Bussey, H. E., *V-P.*, 1923–25.

Carle, N. A., *M.*, 1916–19; *V-P.*, 1919–20.
*Carlton, W. G., *M.*, 1908–11; *V-P.*, 1911–13.
Carpenter, H. V., *V-P.*, 1930–32.
*Carty, John J., *M.*, 1893–96; 1900–03; 1903–04; 1906–08; *V-P.*, 1904–06; 1908–11; *P.*, 1915–16.
*Chamberlain, J. C., *M.*, 1890–93.
Charlesworth, H. P., *M.*, 1923–27; *V-P.*, 1930–32; *P.*, 1932–33.
Chesney, C. C., *M.*, 1905–08; *V-P.*, 1908–10; *P.*, 1926–27.
Chesterman, F. J., *D.*, 1926–30.
Chubb, L. W., *D.*, 1931– .
Chubbuck, L. B., *V-P.*, 1931–33.
†Church, W. Lee, *M.*, 1887–88.
Clarke, Chas. L., *M.*, 1904–05.
Clifford, H. E., *M.*, 1908–11.
Coldwell, O. B., *V-P.*, 1921–22.
*Compton, Alfred G., *M.*, 1891–94.
Cooper, A. B., *V-P.*, 1927–29; *D.*, 1930– .
Copley, A. W., *V-P.*, 1931–33.
*Craft, E. B., *M.*, 1920–24.
Craft, F. M., *V-P.*, 1933– .
*Crocker, Francis B., *M.*, 1888–90; *V-P.*, 1890–92; 1894–96; *P.*, 1897–98.
†Crosby, Oscar T., *V-P.*, 1892–94.
*Cross, Chas. R., *V-P.*, 1884–85.
*Cuttriss, Chas., *M.*, 1888–91.

*Delany, Patrick B., *M.*, 1890–93; *V-P.*, 1893–95.
Del Mar, Wm. A., *M.*, 1917–21; *V-P.*, 1921–22.
Dobson, W. P., *V-P.*, 1925–27.
*Dolbear, A. E., *V-P.*, 1885–87.
Don Carlos, H. C., *D.*, 1926–30.
Downing, P. M., *V-P.*, 1925–27.
*Duncan, Louis, *P.*, 1895–97.
Dunn, Gano, *M.*, 1897–1900; *V-P.*, 1900–02; *M.*, 1902–05; *V-P.*, 1905–07; *P.*, 1911–12.

Eales, H. W., *V-P.*, 1921–26.
*Eckert, W. H., *M.*, 1884–85.
*Edgar, Chas. L., *M.*, 1905–08.
*Edison, Thos. A., *V-P.*, 1884–85.
*Eglin, W. C., *M.*, 1903–06; *V-P.*, 1907–09.
Emmet, W. L. R., *V-P.*, 1900–02.
Evans, Herbert S., *V-P.*, 1929–31.
Ewart, F. R., *V-P.*, 1921–23.

*Faccioli, G., *M.*, 1918–22; *V-P.*, 1922–24.
Ferguson, Louis A., *M.*, 1904–07; *V-P.*, 1907–08; *P.*, 1908–09.
Ferguson, O. J., *V-P.*, 1927–29.
*Field, Stephen D., *M.*, 1884–86.
*Finney, John H., *M.*, 1914–17; *V-P.*, 1917–18.
Fisken, John B., *M.*, 1916–19; *V-P.*, 1919–20.
Fleager, C. E., *V-P.*, 1929–31.
*Foster, Horatio A., *M.*, 1890–93.
Fowle, F. F., *M.*, 1919–23.
*Fowler, A. C., *M.*, 1887.
Fowler, M. M., *D.*, 1925–29.
Freeman, W. E., *V-P.*, 1931–33.

*Geyer, Wm. E., *M.*, 1888–92.
Gherardi, Bancroft, *M.*, 1905–08; 1914–17; *V-P.*, 1908–10; *P.*, 1927–28.
Goldsborough, W. E., *M.*, 1901–04; *V-P.*, 1904–06.
*Gray, Elisha, *M.*, 1884–86.
*Green, Norvin, *P.*, 1884–86; *V-P.*, 1886–88.
*Greene, S. Dana, *M.*, 1899.
Hall, Walter A., *M.*, 1917–21; *V-P.*, 1921–22.
*Hamblet, Jas., *M.*, 1891–94; *V-P.*, 1894–96.
Hamilton, George A., *V-P.*, 1884–86; *Natl. Treas.*, 1895–1930.
*Hammer, William J., *V-P.*, 1891–93; *M.*, 1893–96.
Hanker, F. C., *D.*, 1927–31.
Harisberger, John, *V-P.*, 1924–26.
*Haskins, Chas. H., *V-P.*, 1884–86.
*Hasson, W. F. C., *V-P.*, 1895–97; *M.*, 1897–1900.
*Hazard, Rowland R., *Treas.*, 1884–86; *V-P.*, 1887–89.
*Hellings, M. L., *M.*, 1884–85.
Henderson, S. E. M., *V-P.*, 1923–25.
Henline, H. H., *Act. Natl. Secy.*, 1932; *Natl. Secy.*, 1933– .
*Hering, Carl, *V-P.*, 1891–93; 1895–98; *P.*, 1900–01.
*Herzog, F. Benedict, *M.*, 1887–92.
†Hewitt, Chas., *M.*, 1893–96.
†Hibbard, Angus S., *M.*, 1892–95; *V-P.*, 1895–97.
Higson, C. R., *V-P.*, 1932– .
Hobart, H. M., *M.*, 1922–26; *V-P.*, 1926–28.
*Houston, Edwin J., *M.*, 1884–87; *P.*, 1893–95.
Howell, John W., *M.*, 1888–90.
Hull, A. H., *V-P.*, 1933– .
Hull, B. D., *V-P.*, 1928–30; *D.*, 1931–.
Humphrey, H. H., *V-P.*, 1906–08.
Hunting, F. S., *M.*, 1911–14; *V-P.*, 1914–16.
Hutchinson, Cary T., *M.*, 1895–98; *V-P.*, 1898–1900.
*Hutchinson, F. L., *Natl. Secy.*, 1912–32.

Imlay, L. E., *M.*, 1919–23.

Jackson, Dugald C., *V-P.*, 1897–99; *P.*, 1910–11.
Jackson, W. B., *M.*, 1912–15; *V-P.*, 1918–19.
James, Wm. F., *V-P.*, 1923–25.
Jamieson, B. G., *V-P.*, 1926–28.
Jewett, F. B., *M.*, 1915–18; *V-P.*, 1918–19; *P.*, 1922–23.
Johnson, J. Allen, *D.*, 1928–32; *V-P.*, 1932– .
*Jones, Francis W., *M.*, 1884–85; *V-P.*, 1885–87.
Jorgensen, L. R., *V-P.*, 1919–20.
Juhnke, P. B., *D.*, 1933– .
*Junkersfeld, P., *M.*, 1913–16; *V P.*, 1916–18.

Kearns, J. E., *D.*, 1929–33.
*Keith, Nathaniel S., *Secy.*, 1884–85.
Kelsch, Raymond S., *V-P.*, 1918–19.
Kennelly, Arthur E., *V-P.*, 1892–94; *M.*, 1894–97; *V-P.*, 1897–98; *P.*, 1898–1900.
Kidder, H. A., *M.*, 1925–28; *V-P.*, 1928–30.
Knight, G. L., *M.*, 1922–26; *V-P.*, 1926–28.
Knowlton, A. E., *D.*, 1930– .
Kositzky, G. A., *D.*, 1932– .
Kouwenhoven, W. B., *V-P.*, 1931–33.

Lacy, T. N., *V-P.*, 1930–32.
*Lamme, Benj. G., *M.*, 1907–10.
Lardner, H. A., *M.*, 1913–16.
Lee, Everett S., *D.*, 1933– .
*Lee, William S., *M.*, 1911–14; *D.*, 1929–30; *P.*, 1930–31.
*Leonard, H. Ward, *M.*, 1890–93; *V-P.*, 1893–95.
*Lieb, John W., *M.*, 1896–99; *V-P.*, 1899–1901; *M.*, 1901–03; *V-P.*, 1903–04; *P.*, 1904–05.
*Lighthipe, J. A., *V-P.*, 1913–15.
Lincoln, J. F., *M.*, 1920–24.
Lincoln, Paul M., *M.*, 1906–09; *V-P.*, 1909–11; *P.*, 1914–15.
Liversidge, H. P., *D.*, 1927–31.
*Lloyd, Herbert, *M.*, 1898–1901.
*Lockwood, Thos. D., *V-P.*, 1886–87; *M.*, 1888–90; *V-P.*, 1891–93.
Lovell, A. H., *D.*, 1932– .
*Lozier, R. T., *M.*, 1902–04.
Lunn, Ernest, *M.*, 1922–26.

MacCutcheon, A. M., *D.*, 1928–32.
Macdonald, J. E., *V-P.*, 1923–25.
*Macfarlane, Alexander, *M.*, 1897–1900.
Maclachlan, Wills, *V-P.*, 1919–20.
Magnusson, C. E., *V-P.*, 1920–21.
*Mailloux, C. O., *M.*, 1886–89; *V-P.*, 1898–99; *M.*, 1899–1902; *V-P.*, 1902–04; *M.*, 1905–07; *P.*, 1913–14.
*Martin, T. Commerford, *Act. Secy.*, 1884–85; *M.*, 1885–87; *P.*, 1887–8; *V-P.*, 1888–90.
Martindale, E. H., *M.*, 1917–20; *V-P.*, 1920–21.
*Maver, Wm., Jr., *M.*, 1888–91.
*Maynard, Geo. C., *V-P.*, 1886–88.
McAllister, A. S., *M.*, 1914–17; *V-P.*, 1917–18.
McClellan, William, *M.*, 1912–15; *V-P.*, 1915–17; *P.*, 1921–22.
†McConahey, W. M., *M.*, 1923–27.
McDowell, C. S., *V-P.*, 1920–21.
Merriam, E. B., *M.*, 1924–28; *V-P.*, 1928–30.
Mershon, Ralph D., *M.*, 1900–03; *V-P.*, 1903–05; *P.*, 1912–13.
Meyer, E. B., *D.*, 1927–31; *V-P.*, 1932– .
*Michaelis, O. E., *M.*, 1886–89; *V-P.*, 1889–90.
Mills, G. A., *V-P.*, Aug.–Oct. 1932.

Mitchell, W. E., *V-P.*, 1925–27.
Morehouse, L. F., *M.*, 1919–23; *V-P.*, 1924–26.
Morrow, L. W. W., *D.*, 1933– .
Moultrop, I. E., *D.*, 1926–30; *V-P.*, 1930–32.
*Mullin, E. H., *M.*, 1902–04.
Murray, Wm. S., *M.*, 1908–09; 1909–12; *V-P.*, 1912–14.

Newbury, F. D., *M.*, 1918–22.
Nichols, E. L., *V-P.*, 1889–91.
Norris, H. H., *M.*, 1909–12.
Northmore, E. R., *V-P.*, 1927–29.

*Osgood, Farley, *M.*, 1911–14; *V-P.*, 1914–16; *P.*, 1924–25.
†Owens, R. B., *V-P.*, 1898–1900.

Parker, J. C., *V-P.*, 1921–22.
Patton, P. H., *V-P.*, 1931–33.
*Peek, F. W. Jr., *D.*, 1930–33.
Pender, Harold, *M.*, 1915–18; *V-P.*, 1918–19.
*Perrine, Frederick A. C., *M.*, 1898–1900.
*Phelps, Geo. M., Jr., *M.*, 1885–87; *Treas.*, 1886–95.
*Pickernell, F. A., *M.*, 1896–99.
Pierce, A. G., *M.*, 1921–25; *V-P.*, 1925–27.
Plumb, H. T., *V-P.*, 1922–24.
*Pope, Franklin L., *V-P.*, 1884–86; *P.*, 1886–87; *V-P.*, 1887–89.
*Pope, Ralph W., *Secy.*, 1885–1911; *Hon. Secy.*, 1911–29.
Pratt, H. A., *M.*, 1921–25.
*Prescott, Geo. B., *M.*, 1884.
*Prescott, G. B., Jr., *M.*, 1888–1891.
Puffer, Wm. L., *M.*, 1896–99.
Pupin, Michael I., *M.*, 1892–95; *V-P.*, 1895–97; 1901–03; *P.*, 1925–26.

Quinan, G. E., *V-P.*, 1928–30.

*Reber, Samuel, *M.*, 1901–04; *V-P.*, 1904–06.
Rice, Calvin W., *M.*, 1900–03; *V-P.*, 1903–05.
Rice, E. W., Jr., *P.*, 1917–18.
†Robbins, Chas., *M.*, 1916–20; *V-P.*, 1920–21.
*Robinson, L. T., *M.*, 1913–16; *V-P.*, 1916–18; 1920–21.
Rodman, W. S., *V-P.*, 1929–31.
Ruffner, Chas. S., *M.*, 1916–20; *V-P.*, 1920–21.
Rugg, W. S., *M.*, 1910–13.
Rushmore, D. B., *M.*, 1908–11; *V-P.*, 1911–13.

Ryan, Harris J., *M.*, 1893–96; *V-P.*, 1896–98; *P.*, 1923–24.
Ryan, W. T., *V-P.*, 1928–30.

Sands, Herbert S., *V-P.*, 1923–27.
*Sargent, W. D., *M.*, 1885–86.
*Schoen, A. M., *M.*, 1906–09; *V-P.*, 1919–20.
Schoolfield, H. H., *V-P.*, 1926–28.
*Schuchardt, R. F., *V-P.*, 1922–24; *P.*, 1928–29.
Scott, Chas. F., *M.*, 1895–98; *V-P.*, 1899–1901; *P.*, 1902–03.
*Scribner, Chas. E., *M.*, 1910–13; *V-P.*, 1913–15.
Sever, Geo. F., *M.*, 1898–1901; *V-P.*, 1901–03; *M.*, 1903–06.
Shaad, G. C., *V-P.*, 1930–32.
*Shelbourne, Sidney F., *M.*, 1886–87.
*Sheldon, Samuel, *M.*, 1898–1901; *V-P.*, 1901–03; *M.*, 1903–06; *P.*, 1906–07.
Sibley, R., *V-P.*, 1921–23.
Sisson, C. E., *V-P.*, 1929–31.
Skinner, C. E., *M.*, 1915–19; *V-P.*, 1919–20; *P.*, 1931–32.
Slichter, Walter I., *M.*, 1918–22; *V-P.*, 1922–24; *Natl. Treas.*, 1930– .
*Smith, H. B., *M.*, 1920–24; *V-P.*, 1924–26; *P.*, 1929–30.
*Smith, W. W., *M.*, 1884–85.
Sorensen, R. W., *V-P.*, 1933– .
*Spencer, Paul, *M.*, 1906–09; *V-P.*, 1909–11.
Sprague, Frank J., *V-P.*, 1890–92; *P.*, 1892–93.
*Springer, F. W., *V-P.*, 1921–23.
Sprong, S. D., *M.*, 1909–12; *V-P.*, 1912–14.
*Stanley, Wm., *V-P.*, 1898–1900.
*Steinmetz, Chas. P., *M.*, 1892–95; *V-P.*, 1896–98; *M.*, 1898–1901; *P.*, 1901–02.
Stephens, C. E., *D.*, 1928–33.
Stevens, A. C., *D.*, 1932– .
*Stevens, J. Franklin, *M.*, 1912–15; *V-P.*, 1915–17.
Stillwell, Lewis B., *M.*, 1896–99; *V-P.*, 1899–1901; *P.*, 1909–10.
†Stine, Wilbur M., *V-P.*, 1896–98.
Stokes, Stanley, *V-P.*, 1932– .

Stone, Chas. W., *M.*, 1908–11; *V-P.*, 1911–13.
Stone, E. C., *D.*, 1925–29; *V-P.*, 1929–31.
Storer, Norman W., *M.*, 1911–14; *V-P.*, 1914–16; 1921–23.
*Stott, Henry G., *M.*, 1904–07; *P.*, 1907–08.
Sykes, Wilfred, *M.*, 1917–21.

Tapscott, R. H., *D.*, 1930– .
Taylor, John B., *M.*, 1915–18; *V-P.*, 1918–19.
Terry, Chas. A., *M.*, 1902–05; *V-P.*, 1905–07.
Tesla, Nikola, *V-P.*, 1892–94.
*Thomas, B. F., *M.*, 1885–87.
Thomas, Percy H., *M.*, 1907–10; *V-P.*, 1910–12.
†Thompson, Edward P., *M.*, 1887–88.
Thomson, Elihu, *V-P.*, 1887–89; *P.*, 1889–90.
*Townley, Calvert, *M.*, 1905–08; *V-P.*, 1908–10 *P.*, 1919–20.
Townsend, Henry C., *M.*, 1899–02.
*Trowbridge, Wm. P., *M.*, 1884–86.

*Upton, Francis R., *V-P.*, 1889–90; *M.*, 1890–92.

*Vail, Theo. N., *M.*, 1884–86.
Vanderpoel, W. K., *M.*, 1923–27.
*Van Hoevenbergh, H., *M.*, 1888–90.
*Vansize, W. B., *M.*, 1894–97.

*Wallace, Wm., *V-P.*, 1893–95.
*Weaver, W. D., *M.*, 1894–97; 1899–1902.
†Webb, Herbert L., *M.*, 1891–94; 1897–1900.
Weston, Edward, *M.*, 1884–87; *P.*, 1888–89; *V-P.*, 1889–91.
*Wetzler, Jos., *M.*, 1888–90; *V-P.*, 1890–2.
*Wheeler, Schuyler S., *M.*, 1887–90; *V-P.*, 1890–91; 1902–04; *M.*, 1904–05; *P.*, 1905–06.
White, Jas. G., *M.*, 1904–07; *V-P.*, 1907–09.
Whitehead, John B., *M.*, 1924–28; *P.*, 1933– .
*Williamson, R. B., *M.*, 1921–25.
Wilson, A. M., *V-P.*, 1933– .
*Wirt, Chas., *M.*, 1892–95.
*Wolcott, Townsend, *M.*, 1902–05; *V-P.*, 1905–07.
Woodrow, H. R., *D.*, 1931– .

Abbreviations, *P.*, President; *V-P.*, Vice-President; *M.*, Manager; *D.*, Director; *Natl. Secy.*, National Secretary; *Secy.*, Secretary; *Hon. Secy.*, Honorary Secretary; *Natl. Treas.*, National Treasurer; *Treas.*, Treasurer.
* Deceased. † Non-members at present.

List of Women Members of the A.I.E.E.

Miss Edith Clarke (A'23–M'33)	Engineer, Central Station Engg., Dept., General Electric Co., Schenectady, N. Y.
Miss Helen W. Hardy (A'26)	Assistant to General Lighting Representative, Public Service Electric and Gas Co., 90 Park Pl., Newark, N. J.
Miss Vivien Kellems (A'30)	President, Kellems, Products, Inc., 100 Lafayette St., New York, N. Y.
Miss Ruth Kern (A'33)	444 Kenwood Road, Drexel Park, Drexel Hill, Pa.
Miss Deany C. LaZan (A'27)	Sales Engineer, Simplex Wire & Cable Co., 2019 Union Trust Bldg., Cleveland, Ohio
Miss Mabel MacFerran (A'28)	Assistant Engineer, Metropolitan Water District of Southern California, 306 West 3rd St., Los Angeles, Calif.
Mrs. Zella A. McBerty (A'24)	Secretary and Treasurer, The Federal Machine and Welder Co., Dana Ave., Warren, Ohio
Mrs. Paul McMichael (A'22)	Electrical Engineer, 530 E. 22nd St., Brooklyn, N. Y.
Mrs. Roland R. Miner (A'30)	820 North Pershing, Wichita, Kans.
Miss Frances H. Pettee (A'27)	Sales Department, Simplex Wire and Cable Co., 79 Sidney St., Boston, Mass.

Sections and Branches of the Institute

THE GROWTH of membership in the Institute led, in 1893, to consideration of the desirability of holding meetings in some of the larger cities. Upon the recommendation of a committee appointed to study the matter, a plan was adopted in November 1893, providing for the holding of local meetings in any city upon petition of 20 members. Subsequently, monthly meetings were held in Chicago, usually on the same evenings as the meetings in New York, with the presentation of the same papers.

Upon his election as president of the Institute in 1902, Charles F. Scott inquired among some of the leading members as to what activities should have special emphasis. Secretary Pope urged the extension of local meetings, a subject in which he long had retained keen interest, and expressed the view that conditions were favorable for further developments. Others agreed upon this need, and certain statements regarding the very rapid developments then occurring in the electrical industries deeply impressed President Scott with the need for better provisions for the training of young engineers who would be required in rapidly increasing numbers.

Consequently, he presented to the board of directors, in September 1902, a report including, among other recommended developments of the Institute, comprehensive proposals concerning the organization of local groups of members in the electrical centers and groups of engineering students in the universities and technical schools, in order to distribute as widely as possible the benefits of affiliation with the work of the

Table I—Record of Institute Sections and Branches

Year Ending April 30	Sections: No. of Sections	Sections: No. of Meetings	Sections: Total Attend.	Branches: No. of Branches	Branches: No. of Meetings	Branches: Total Attend.
1893 to 1901	1					
1902	2			0		
1903	11			7		
1904	16			12		
1905	18			14		
1906	18			14		
1907	18			15		
1908	22	141	7,476	26	143	4,128
1909	23	169	16,427	27	198	8,443
1910	25	187	16,694	31	237	10,255
1911	25	208	15,243	36	255	10,714
1912	28	231	19,800	42	281	10,255
1913	29	244	22,825	47	357	11,808
1914	30	233	22,626	47	306	11,617
1915	31	246	23,507	52	328	12,712
1916	32	251	28,553	54	360	15,166
1917	32	265	31,299	59	368	16,107
1918	34	245	34,614	59	268	10,683
1919	34	217	25,837	61	156	6,441
1920	36	262	30,741	62	360	16,827
1921	42	303	37,823	65	443	21,629
1922	45	373	54,378	67	439	25,358
1923	46	344	46,672	68	503	26,893
1924	47	381	58,945	77	530	25,674
1925	49	386	49,029	82	548	27,603
1926	51	405	58,959	86	714	35,270
1927	52	431	60,708	95	842	42,650
1928	52	431	64,276	96	915	44,334
1929	54	460	73,254	100	940	47,408
1930	56	480	84,615	106	1,009	50,401
1931	59	491	108,523	109	1,137	51,807
1932	60	497	105,325	109	1,135	54,197
1933	60	498	73,806	111	1,026	59,439
1934	61			113		

Table II—Record of A.I.E.E. Membership

Year Ending May 1	Total Membership	Year Ending May 1	Total Membership
1884	71	1910	6,681
1885	209	1911	7,117
1886	250	1912	7,459
1887	314	1913	7,654
1889	333	1914	7,876
1890	427	1915	8,054
1891	541	1916	8,212
1892	615	1917	8,710
1893	673	1918	9,282
1894	800	1919	10,352
1895	944	1920	11,345
1896	1,035	1921	13,215
1897	1,073	1922	14,263
1898	1,098	1923	15,298
1899	1,133	1924	16,455
1900	1,183	1925	17,319
1901	1,260	1926	18,158
1902	1,549	1927	18,344
1903	2,229	1928	18,265
1904	3,027	1929	18,133
1905	3,460	1930	18,003
1906	3,870	1931	18,334
1907	4,521	1932	17,550
1908	5,674	1933	17,019
1909	6,400	1934	15,200

The number of members given in this table is that compiled from the membership lists of May 1, of each year, except that no satisfactory list was available in 1888, which necessitated the use of the list of December 1, 1887. During the first few years the number of members carried on the rolls was greater than the number of active members. This situation was explained in the report of the secretary on May 18, 1886, and also in the report of May 17, 1887. (TRANS. v. 3, p. 12; BUS. PROC. May 17, 1887, p. 2). At the time of the founding of the Institute many names were proposed as eligible for membership and were counted as members. Many of these did not respond to communications, and a circular was prepared requesting that they definitely state their intentions. As a result of this, 70 names were dropped from the rolls. For this reason the membership given as 279 in the report for May 19, 1885, has been reduced to 209.

Institute. The board of directors promptly approved the organization of such local groups, now known as Sections and Branches.

The membership of the Institute on May 1, 1902, was 1,549, and it was the smallest of the 4 societies of civil, electrical, mechanical, and mining engineers. The numbers of sections and Branches increased rapidly after the fall of 1902, and the very rapid increase in membership brought the Institute to a total of more than 4,000 less than 5 years later, and made it the largest of the 4 societies, a distinction which it held until 1915. Steady increases in the numbers of Sections and Branches have continued during the period of 32 years, and the totals now are 61 and 113, respectively. In Table I is shown a record of the growth of Institute Sections and Branches, and in Table II is a record of total membership.

The activities of these local groups have expanded rapidly, especially during the past few years. Further information may be found in the annual report on Section and Branch activities for the fiscal year ending April 30, 1933, which was published on pages 426–28 of the June 1933 issue of ELECTRICAL ENGINEERING. The report for the present fiscal year is scheduled to appear in the June 1934 issue.

International Engineering Congresses

PRIOR to the Centennial Exposition in Philadelphia in 1876, the use of electricity had been practically limited to electroplating and to various forms of signaling, of which the telegraph was the most important. Only 8 years later, in 1884, the prospects of very rapid further developments, especially in electric lighting and electric railways, were such that the leaders "recognized the necessity of a society which should foster and encourage electrical applications in every useful art."

The American Institute of Electrical Engineers took its place among these new developments through a preliminary meeting held on April 15, 1884, as a result of the efforts of Dr. Nathaniel S. Keith, and an organization meeting on May 13, 1884.

At the time of its organization, preparations were in progress for an International Electrical Exhibition to be held in Philadelphia under the auspices of the Franklin Institute. During the exhibition, a National Conference of Electricians was held September 8–13, 1884, attended by about 100 "electricians" from Europe and America.

The first meeting of the Institute was held October 7 and 8, in connection with the exhibition, and 11 papers were presented. Thus, the early life of the Institute was closely related to an international conference, and, in fact, it appears that the conference was one of the principal influences causing the Institute to be organized in that year.

During the next few years, the Institute developed its activities and soon became established as a strong engineering society. Much interest was shown in proper efforts to identify it with international work and thus to secure recognition of the important researches of Americans.

The Institute appointed 5 delegates who attended a congress held in Paris in 1889, in connection with an international exposition, and appointed a delegation of 5 members to attend the Frankfort International Congress in 1891.

Beginning in 1891, the Institute made extensive preparations for the International Electrical Congress held in Chicago, August 21–25, 1893, in connection with the World's Columbian Exposition. On June 24, 1893, appropriately furnished and decorated rooms, in the electricity building at the exposition, were opened by the Institute to receive visitors. The register showed a total "of 612 visitors, among whom were many of the most distinguished electricians of the day."

The above will suffice to show the emphasis placed upon the international congresses during the first 20 years of the Institute's life. Since then, with the constantly expanding scope and increasing importance of international relations among engineers and scientists, the Institute and many of its leading members have participated in numerous international conferences, some of the more important being listed as follows:

International Electrical Congress, St. Louis, Mo., Sept. 12–17, 1904.

International Electrical Congress, Turin, Italy, Sept. 1911.

International Electrical Congress, San Francisco, Calif., Sept. 20–25, 1915.

International Engineering Congress, Rio de Janeiro, Brazil, Sept. 7–30, 1922.

World Power Conference, London, England, June 30–July 12, 1924.

World Engineering Congress, Tokyo, Japan, Oct. 28–Nov. 7, 1929.

International Electrical Congress, Paris, France, July 4–12, 1932.

The A.I.E.E. in Standardization

THE FIRST Institute committee to have anything to do with standardization came into being in 1889 "to formulate and submit for approval a standard wiring table." It was not, however, until 1898 that the first standardization committee, dealing with standards for electrical machinery and apparatus, was appointed. This committee decided to devote its efforts to the standards of performance, leaving matters of construction, dimensions, and design to the manufacturer. The wisdom of that early established policy is proved by the fact that almost without exception it has been adhered to with unqualified success down to the present day.

Out of the chaos that first committee faced there grew a recognized procedure for setting up apparatus standards through which all interested parties were given representation on A.I.E.E. standards making subcommittees. A series of nationally recognized electrical standards developed thus, devoted almost entirely to a definition of the terms and conditions which characterize the rating and behavior of electrical machinery and apparatus.

With the tremendous growth of the electrical industry in the United States, other organizations, professional and trade, sprang into being. They had a considerable interest in electrical standardization. Other standards were developed, sometimes overlapping. There was much duplication of work. Finally, it became evident that continued progress depended upon the formation of a central body on which all could have duly accredited representatives. From a plan promulgated within the A.I.E.E. standards committee, but in collaboration with the national societies of civil, mining, and mechanical engineers, there was eventually established the American Engineering Standards Committee, or as it is now known, the American Standards Association.

The Institute today still maintains its standardizing machinery, while coöperating to the fullest extent with the A.S.A. in the formulation of American standards. It is, however, acting largely as the originator of new standards, for through the discussions in the Institute technical committees the needs of the industry early became evident. The technical committees have therefore largely taken over the work formerly carried on by the subcommittees of the standards committee. The results of the technical committees standards activities all clear through the standards committee, which decides on final disposition. It also, from time to time, suggests fields of activity to the technical committee properly concerned. As Institute standards, either existing or new, reach a status seeming to warrant approval as American standards they are submitted to A.S.A. for action. At the present time over 20 former A.I.E.E. standards have received such recognition.

Probably at the present time the 2 projects of greatest moment to the entire electrical field developing under A.I.E.E. auspices are the series of test codes for electrical machinery and apparatus, and the proposed American standards for electrical definitions.

The test codes, of which 2 are available, as reports, meet a long felt need in that they provide in convenient form the more generally applicable and accepted methods of conducting and reporting tests of a commercial nature, which apply to the fulfillment of performance guarantees and to acceptance tests.

The glossary of electrical terms, the first report of which was issued in August 1932, will eventually contain over 5,000 definitions. Over 300 men have been at work on this proposition.

The Institute has also taken a leading part in international standardization. In 1904, when the international standardization call came, it was headed by the A.I.E.E., and, as a result, the Institute served for many years as the godfather of the United States National Committee of the International Electrotechnical Commission. While the difficulties have been great in international standardization there is now at least a language of common understanding in the various large industrial nations. This activity has now passed to the auspices of the A.S.A.

Such is the story in abstract of the A.I.E.E. in standardization.

Engineering Societies Library

THROUGH exchange lists established after the monthly publication of the A.I.E.E. PROCEEDINGS was begun in 1888, the Institute gradually accumulated valuable files of periodicals. In 1900, the first definite appropriation was made for the binding of periodicals and the erection of shelving.

Important new and old electrical and scientific books were contributed to the Institute from time to time singly and in sets, and, in 1901, Dr. Schuyler Skaats Wheeler presented the Latimer-Clark collection of books, pamphlets, and manuscripts, including about 7,000 titles. Andrew Carnegie presented cash equivalent of the Wheeler gift to be used in the preparation of a catalog of the Latimer-Clark collection.

The other national engineering societies had likewise built up libraries for the use of their members, and in 1913, the libraries of the societies of mechanical, mining, and electrical engineers were combined to form a free public engineering library to be known as the Engineering Societies Library. The library of the American Society of Civil Engineers was added in 1916, and a composite card catalog of the entire library was prepared during succeeding years.

With its large collection of books and periodicals on engineering and scientific subjects, its complete card index, and its well-trained staff, this library is prepared to serve effectively in practically the entire engineering field, and is one of the most important joint activities of the 4 societies.

Important new books are added promptly, and subscriptions and exchange arrangements bring to the library all of the more important technical periodicals published in all parts of the world.

The library operates a service bureau and a book lending plan which enable members of the societies located anywhere to make use of its facilities by mail.

The Engineering Foundation

ENGINEERING FOUNDATION was established in 1914 by the 4 national societies of civil, mining and metallurgical, mechanical, and electrical engineers "for the furtherance of research in science and in engineering, or for the advancement in any other manner of the profession of engineering and the good of mankind." It was conceived by Ambrose Swasey, of Cleveland, Ohio, and toward its endowment he has made gifts intended as the nucleus of a "community trust" for engineers, to be contributed by many donors.

The Engineering Foundation Board has 12 members, 2 representatives of each founder society, 3 members-at-large chosen by the board of trustees, and the president of the United Engineering Trustees, Inc., *ex-officio*. This board has discretionary power in disposition of income from the Engineering Foundation Fund and other sources, but responsibility for administration of principal lies with the Board of Trustees.

The Engineering Foundation enjoys the coöperation of engineering societies, National Research Council, technical bureaus of the Government, universities, scientific associations, industries, bankers, and individual engineers. Foundation's endowment aggregates $880,000. The services, facilities, and materials given in addition have been estimated at $2,000,000. In the 20 years of its existence, it has aided in establishing National Research Council and has coöperated in researches in arch dams, steel columns, earths and foundations, blast furnace slags, properties of steam, lubrication of machinery, strength of gears, fundamentals of dielectrics, electric welding, and pure iron electrodes. It has worked through assistance rendered to the Society for the Promotion of Engineering

Education toward the betterment of engineering education and under its auspices there have been conducted 10 courses for disengaged engineers.

Origin and Adoption of the Institute's Badge

THE HISTORY of the development of the present badge of the Institute contains several items of interest, reflecting ideas and personalities of some 40 years ago. The fundamental form of the present badge dates back to 1897, when the original form, adopted in 1893, was superseded.

The first public mention of a badge appears to be in the report of the October 21, 1890, meeting of the council of the A.I.E.E. On that date the council "on motion of Dr. Schuyler Skaats Wheeler, voted that the secretary be instructed to secure a design for a badge and present the same to the council."

December 16, 1890, on motion of Doctor Wheeler, it was voted "that the design for a badge be laid upon the table." At a meeting on October 27, 1891, a letter was read from F. L. Woodward, enclosing a sample of a society pin. On motion of W. J. Hammer (Mr. Hammer's obituary item appears in the news section of this issue) it was voted that "the letter and sample be referred to the committee on certificate of membership, and that members generally be invited to contribute competitive designs." On October 27, 1891, the committee (Messrs. Herzog, Bell, and Foster) asked for advice, and was continued with the understanding that further designs should be secured. On February 16, 1892, Doctor Bell of the committee, submitted several designs which were examined. On motion of Professor Compton it was voted that the committee be instructed

The official badge of the Institute during the period 1893–97. This badge was about 15/16ths of an inch high

to prepare new designs embodying as principal features the kite and the electromagnet, with the initials of the Institute if there were sufficient space. Progress reports of the committee were presented at various council meetings, until, at a meeting of February 21, 1893, "on motion of Professor Compton, it was voted that the design for a badge presented by the committee be accepted and that the design be adopted as the badge of the Institute. It was also voted that the design of the badge be placed upon the certificate and the literature and stationery of the Institute."

Design of the Original Badge

This original badge appeared on the front cover of the monthly Transactions of the Institute from August 1893 to April 1897, and was worn by the members during those years. The badge, shown in the accompanying reproduction, was of white enamel, the lettering and front portions of 18-karat gold, and the backing of 14-karat gold. The design was in the form of Franklin's kite, which demonstrated the identity between lightning and electricity, and was a recognition of America's first "electrician" and philosopher, Benjamin Franklin. The arms or border of the kite formed a diagrammatic representation of the wheatstone bridge. In the center was a tiny galvanometer, representing magnetism and induction. The galvanometer contained a blued steel needle, over which was a small disc of amber. The amber represents the first conception of electricity, dating back to 600 years B.C., when Thales, the Greek philosopher, recorded the fact that amber, when rubbed, attracted light particles to it; and the Greeks worshipped it, believing the Gods had endowed it with life and that it possessed a soul. Amber also represents the derivation of the word electricity, as Doctor Gilbert, court physician to Queen Elizabeth and in the year 1600 A.D., coined the word electricity from the Greek word for amber, which is elektron.

Above the galvanometer were the letters A.I.E.E., the initials of the Institute; and below the galvanometer $C=\frac{E}{R}$, representing Ohm's law.

New Badge Adopted in 1897

This badge apparently was not considered entirely satisfactory, and at a meeting of the council, November 20, 1895, a petition signed by 20 members was read, asking that steps be taken to secure a better design. A committee was appointed, consisting of W. J. Hammer, W. D. Weaver, M. I. Pupin, W. A. Anthony, and S. S. Wheeler, which made a final report March 24, 1897, "with designs and a sample" which was referred to the annual meeting for consideration. The report of the annual business meeting of May 18, 1897, included "at the conclusion of the discussion. . . the matter of the design reported by the committee was adopted." This emblem, essentially unchanged since 1897, has held and continues to hold a prominent place in Institute publication. It first appeared on the cover of the monthly Transactions for May 1897, and, with only slightly changed proportions, now appears on the cover of each issue of Electrical Engineering.

In a letter dated October 20, 1914, Dr. S. S. Wheeler, who was chairman of the above-mentioned committee on design of the present badge, stated that the design was chosen "after considerable thought, as a symbol of the broadest principle that could be found underlying our profession. Electricity always surrounds magnetism and magnetism always surrounds electricity and each forms a closed circuit; therefore the relation between them is always that of 2 closed links which pass through each other, and this holds true of course in every application of electricity or magnetism."

Form of the Present Badge

Several variations on the fundamental form of the present badge, shown in the illustration, are used to indicate different grades of membership. Except for the Student badge, which is of somewhat different design, the different forms are determined by the color and placing of the enamel. The Associate badge has an enameled background of maroon, with letters and border in gold. The badge for Members is similar except that the back ground is enameled in blue, while the badge for Fellows is the reverse in color of that provided for Members. On the badge for Students, the 2 circles surrounding the letters "E.E." are not used, and a large letter "S" extends from top to bottom of the badge, almost circling the "A" and "I"; the enamel background is black with gold letters and border.

There are several special badges, the form of which is similar to that for Associ-

The fundamental form of badge adopted by the Institute in 1897 and used, with only minor changes in proportion, continuously since then. The badge is of gold and with different colors of enamel used to indicate the grade of membership

ates, Members, and Fellows. The badge for Presidents has blue letters and blue circles on a gold background, with a white line just inside the gold border. The badge for Honorary Members has a white enamel background, with gold letters and border. The special badge to be presented the 6 living charter members at the Institute's summer convention this June, has a gold background, with blue letters and white circles, and a blue line extending around the badge just inside the gold border.

Some Contrasts in Power System Switchboards

Office of the load dispatcher in Oakland, Calif., as it appeared in 1907 (right) and (below) as it is today

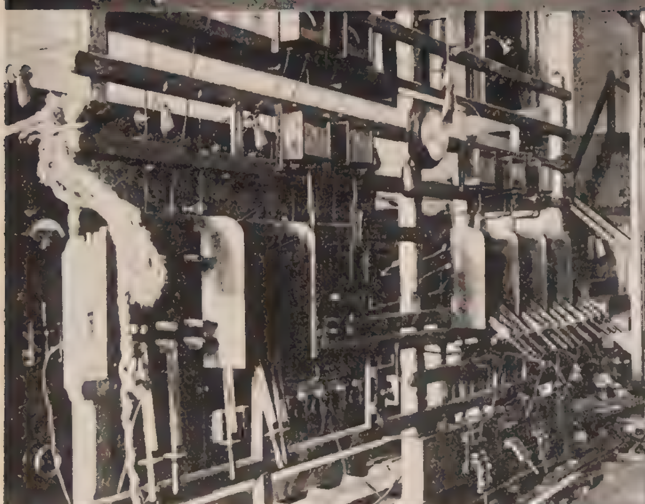
(Pacific Gas and Elec. Co. photo)

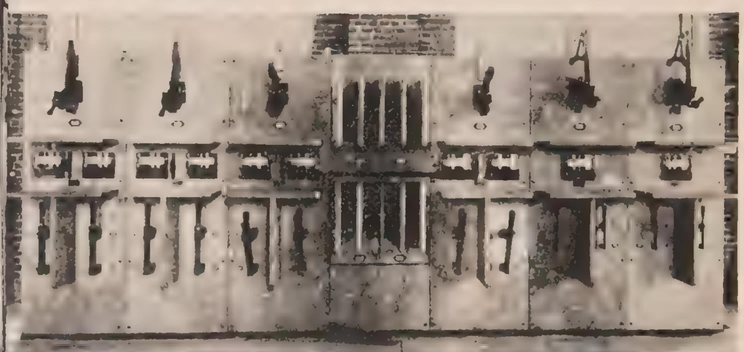
(Above) When a switchboard was really a board with switches on it—a type of construction used 40 years ago

(Westinghouse photo)

(Below) One of the early switchboards using marble instead of wood. Note the heavy baffle boards between switches

(General Electric photo)





(Above) The original switchboard of Mill Creek No. 1 (Calif.) hydroelectric station. It was replaced by the one seen in the rear

(Southern Calif. Edison Co. photo)

(Right) Supervisory control room for the entire power distribution system of the Cincinnati Street Railway Company. This system has a total capacity of 33,500 kw in rotary converters distributed among 20 automatic substations, for which constant supervision is provided

Significant Electrical Developments

SOME technological discoveries and developments of particular significance to the electrical industry, starting with the year 1729 and extending to the present day, are shown on this and the facing page.

In the chart extending diagonally upward across these pages, the significant developments during the 50-year existence of the A.I.E.E. are shown. This chart is based upon information supplied by the American Telephone and Telegraph Company, the General Electric Company, the Westinghouse Electric and Manufacturing Company, and other authoritative sources.

In the list that starts below on this page and is continued on the right-hand side of the facing page, the significant developments in the 155 years immediately preceding the founding of the Institute in 1884 are given. The items in this list are credited to Thomas G. Lockwood, a charter member of the Institute, who was, during his lifetime, an electrical expert and patent attorney, being in charge of the patent department of the American Bell Telephone Company for several years following 1881.

The history of electrical developments has been classified by one authority in 4 eras. The first of these, termed "frictional electricity," extends from the discovery of the electrical properties of amber in 600 B.C. to Franklin's experiments about 1750 A.D.; during the latter part of this period Dr. William Gilbert, court physician to Queen Elizabeth, undertook numerous scientific experiments. The publication about 1600 of his book "De Magnete Magneticisque Corporibus et de Magnete Tellure Physiologica" (London, Eng.) is credited by many as ushering in the earliest beginnings of scientific research. The second era of electrical development is classified as that of "battery current," and begins with Volta's discovery of his battery in 1800. The third period, that of "electric power" (dynamos), was ushered in by Faraday's discovery of electromagnetic induction in 1831. The fourth period, termed the "electronic" era, dates with the discovery of the "Edison effect" in 1883.

SIGNIFICANT ELECTRICAL DEVELOPMENTS, 1729–1883

1729 July 3—Electrical insulation discovered by Stephen Gray.

1747 July 14—Electricity passed through a wire across the Thames over Westminster Bridge, the circuit being completed through the water.

1752 July 4—Benjamin Franklin demonstrated the identity between lightning and electricity by flying a kite during a thunderstorm.

1753 Feb. 1—First suggestion of the electric telegraph in a communication signed "C. M." in *Scott's Magazine*.

1800 March 20—Alessander Volta announced his invention of the voltaic pile.

1800 April 30—Nicholson and Carlisle discovered the principle of electro-chemical deposition.

1800 Sept. 22—Spark from voltaic battery as observed by Davy announced in Nicholson's Journal.

1800 Oct. 24—First telegraph patent taken out in the United States by Johnathan Grout.

(*Continued on following page*)

1909 1910 1911 1912 1913 1914 1915 1916 1917 1918 1919 1920 1921 1922 1923 1924 1925 1926 1927 1928 1929 1930 1931 1932 1933 1934

- 287 kv transmission line (Boulder Dam to Los Angeles)
- Demonstration of "Auditory Perspective"
- Sodium vapor lamp
- 25,000 kva mercury vapor plant (Schenectady, N. Y.)
- 77,500 kva waterwheel generators (Dnieprostroy)
- Ten million volt artificial lightning
- Overhead a-c networks
- Teletypewriter exchange service
- Automatic steering of airplanes, with drift correction
- Beam communication (42 cm waves; 4–5 watts)
- Twin motor drive for steel mills
- Demonstration of two-way television telephone
- Pulp insulation for telephone cables
- Telephone service between North and South America
- High speed tickers, printing 500 characters per minute
- 200,000 kva single unit turbine generator
- Distance finding station—radio and sound in air (Cape Henry, Va.
- Five million volt artificial lightning
- 10,000-mile telephone conversation (New York to Antarctic)
- First use of 1,800-pair 26-gauge cable for telephone service
- Deionizing principle applied to circuit breakers
- 260,000 kva cross compound turbine generator
- First 132,000-volt oil filled cable
- Hand-set telephone of efficiency equal to that of desk set
- Demonstration of television by wire and radio
- First radio range for aircraft navigation (Hadley Field, N. J.)
- Telephone connection to Mexico, England
- Permalloy in loading coil cores
- Motors of 22,500 h. p. for naval airplane carriers
- Atomic hydrogen welding
- Carrier telephone on deep sea cable
- Nation-wide Stock Exchange quotations
- Arc welding of bridges and buildings
- Electrical transmission of pictures
- Toll cable New York to Chicago
- First turbine generator for 1,200-lb steam pressure
- First loaded (Permalloy) ocean telegraph cable
- Diesel-electric railway locomotive
- 75,000-kva turbine generator
- First commercial mercury vapor turbine in central station (Hartford, Conn.)
- International short wave radio broadcast
- First a-c secondary network (manual; automatic in 1924)
- "Pallophotophone" for talking movies
- 65,000 kva waterwheel generator
- 220,000-volt transformers (So. Calif. Edison Co.)
- Carrier telephone applied to power system
- Radio beacons in N. Y. Harbor
- First fully atomatic panel type telephone exchange
- Deep sea telephone cables Key West to Havana
- Development of one million volts in laboratory experiment
- Radio telephone as extension to land line (Long Beach, Calif.-Catalina Island)
- Radio broadcasting (KDKA, Nov. 2)
- Diesel-electric marine drive
- Carrier telephone circuits in commercial use (Pittsburgh-Baltimore)
- Multi-channel carrier telegraph circuit in commercial use
- 5,625 kva turbine generator (Detroit)
- Supervisory control
- Electrical wave filter
- Electrically driven warships (U. S. S. New Mexico)
- Beginning of general application of printers in communication service
- First transoceanic radio telephone communication
- First commercial use of panel type semi-mechanical telephone system
- First transcontinental telephone (Boston to San Francisco)
- Introduction of high power radio tubes
- Introduction of floodlighting
- C. M. & St. P. electrification 3,000 volt d-c
- 7,000 volt mercury rectifier for railroad electrification
- First commercial use of 1,200-pair 26-gauge cable
- Toll telephone cable (Boston, N. Y., Phila., Washington)
- Panama Canal electrification
- Automatic railway substation (Union, Ill.)
- Printers on transoceanic telegraph cables
- Multiplex printing telegraphy
- Vacuum tube telephone repeater
- Gas filled incandescent lamp
- High frequency alternator for radio (Alexanderson)
- High-voltage X ray equipment
- Lead-antimony replaces lead-tin in cable sheath
- First permanent radio telegraph from U. S. (to Honolulu
- Automatic substation (Detroit Edison)
- Drawn tungsten incandescent lamp filaments
- Opening of New York-Denver telephone line (1800 miles)
- Introduction of quadded telephone cable

Transatlantic radio telegraph service made public
Grand Central Terminal electrification (N. Y. C. R. R.)
Marine turbine electric drive
Interurban 1,200 volt d-c equipment
Suspension disk line insulator
Reversing motors for steel mills
Long distance underground telephone cable
Grid in vacuum tube (De Forest)
Metalized filament incandescent lamp
New Haven R. R. electrification, single phase, [11,000 volts
First main-roll drive for steel mill
Mechanical telephone repeater
Single phase compensated street railway motor
Gas-electric railroad car
Metallic flame arc lamps
6,250 kva turbine generator
Silicon steel transformer cores
9,250 kva waterwheel generators (Niagara Falls)
Magnetite arc lamp
First transatlantic radio telegraph message
Single phase railway system
Mercury rectifier
First U.S. commercial radio telegraph stations
First turbine generators in American central station, [2,000 kva (Hartford, Conn.)
13,200 volt generators
A-c series arc light system
80,000 volt transformers
Mercury vapor lamp
Radio telegraph across English Channel
Invention of telephone circuit loading
33,000 volt transmission
Steam turbine generator, 500 kva
Buckingham high speed printing telegraphy
5,000 kw generators, 43′ in diameter (New York, N. Y.)
5,000 kva oil switch
Multiple unit control system for railroad cars (Sprague)
Constant-current transformer (Thomson)
Chicago elevated railway electrification
Dial replaces push buttons in mechanical telephone system
Marconi application for wireless telegraphy patent (British)
Inductor type alternators
First motor cars, N. Y., N. H. & H.
Motor-driven warship turrets
Baltimore Tunnel electrification (B. & O. R. R.)
Automatic telephone ringing system
Lamp signals on telephone switchboards
Niagara power development—introduction of revolving field 4,500 kva alternators, [power switches, 25 cycles
A-c calculation simplification (Steinmetz)
Vertical shaft waterwheel generators of 500 kw capacity (Oregon City, Ore.)
First common-battery telephone exchange
Commercial induction motor (Columbia, S. C.)
Chicago Worlds Fair; 1,500 kw dc generator; polyphase plant; 850 kva alternators; [display illumination
Direct New York-Chicago telephone line (900 miles)
Commercial mechanical step-by-step telephone system (La Porte, Ind.)
Series-parallel system for railway motors
Polyphase circuits (commercial)
Rotary converter
Dry core paper insulated telephone cable
Sixty cycle adoption as standard frequency
Carbon circuit breaker
Slotted armature d-c generator
Multipolar generator
10,000-volt transmission (Pomona, Cal.)
Bridging bell (telephone)
"Solid back" telephone transmitter
Oil cooled & insulated transformers
A-c power transmission 3,000 v. single ø
A-c arc system
Time signal service by telegraph
Recording wattmeter (Thomson)
Feeder voltage regulator
Induction meter development (Shallenberger)
Tesla patent on induction motor
First electric street railway (Richmond, Va.)
Carbon brushes for motors and generators
A-c transformer system (Thomson-Houston)
Discovery of properties of electromagnetic waves (Hertz)
Experimental installation of induction telegraphy (Lehigh Valley R. R.)
Adoption of commercial telephone desk stand
Transposition on New York-Phila. telephone circuits
Introduction of Edison system of superposed telegraphy
Electric resistance welding
First alternating current central stations
Single phase 133 cycle lighting
First electric driven newspaper presses
Lead tin alloy replaces lead in cable sheath
First New York-Boston hard drawn copper telephone circuit (230 miles)

(Continued from preceding page)

1820 Sept. 15—The invention of the galvanometer announced by Schweigger.

1820 Sept. 25—Arago announced before the French Academy his discovery that a copper wire energized by electricity became magnetic.

1826 July 21—Oersted's discovery of electromagnetism just announced.

1827 Oct. 10—Joseph Henry announces his invention of a practical electromagnet.

1831 Aug. 27—An electric current from a permanent magnet developed by Faraday.

1831 Oct. 1—Faraday produced a current in one circuit by induction from a current flowing in another.

1832 March 30—Magnetic-electric spark first obtained from permanent magnet by Professor Forbes of Edinburgh, Scotland.

1832 Oct. 19—Morse first conceived his idea of an electromagnetic telegraph on board the ship "Sully" between Havre and New York.

1832 Dec. 15—Faraday used the earth to complete a voltaic circuit by means of water and gas pipes.

1836 July 23—Daniell announced the invention of his sulphate-of-copper constant battery.

1836 June 24—First patent in electrometallurgy issued in England to G. R. Elkington.

1836 Dec. 23—Steinheil's telegraph first described in the *Magazine of Popular Science.*

1837 June 6—English patent for electromotor issued to Thomas Davenport of Brandon, Vt.

1837 July 25—English needle telegraph first practically operated on a subterranean line between Easton and Camden Town.

1837 Oct. 2—Morse made his first experiment in telegraphy.

1839 May 4—The invention of electrotyping announced by Jacobi.

1839 May 21—Heat manifested by the transmission of electricity through suitable wire from the gymnotus orelectric eel.

1839 Nov. 2—Electromagnetic motor exhibited in England by Captain Taylor.

1840 June 20—Patent for electromagnetic telegraph issued to Professor Morse.

1841 Aug. 21—First patent describing the incandescent electric lamp issued in England to F. De Moleyns.

1842 Aug. 1—The use of the magneto-electric machine for electrodeposition suggested in a British patent taken out by J. S. Woolrich.

1844 May 24—First message sent over a telegraph wire by the Morse system.

1845 April 1—First American electric telegraph opened for business between Washington and Baltimore.

1845 Nov. 4—Incandescent carbon in a vacuum patented in England by Starr in the name of E. A. King.

1846 April 11—Patent granted to Prof. Morse for his invention of the local circuit operated by a main line relay.

1849 June 10—First experimental submarine cable laid by C. V. Walker, 2 miles out at sea from Folkestone, England.

1851 Feb. 7—Central office system patented by F. M. A. Dumont in England.

1851 April 29—Prof. Charles G. Page makes an experimental trip in his electromagnetic locomotive from Washington to Bladensburg and return, highest speed, 19 mph.

1858 May 18—First arc lamp patent issued in U.S.

1858 Aug. 5—The laying of the first Atlantic cable completed; cable worked for 26 days.

1858 Nov. 24—Dynamo principle described in an English patent.

1858 Dec. 8—Electric light first employed in lighthouse work at So. Foreland, England.

1859 Sept. 20—First patent granted in the U.S for heating by electricity.

1866 July 27—Telegraph communication successfully and permanently established between Europe and America.

1866 Dec. 24—S. A. Varley provisionally patented in England the dynamo principle first described and patented by Hjorth in 1854, and subsequently elaborated in an English patent of 1858.

1867 Jan. 17—Werner von Siemens proposed the name dynamo machine in an address before the Berlin Academy.

1867 Feb. 14—Sir Charles Wheatstone explains the dynamo principle before Royal Soc.

1873 June 3—The reversibility of the dynamo demonstrated by Hippolyte Fontaine.

1875 June 2—First practical form of the Bell Telephone made.

1876 March 7—Patent granted to Alexander Graham Bell for the telephone.

1876 March 23—First patent granted to Jablochkoff for his electric candle.

1876 Brush arc dynamo developed.

1877 April 4—First telephone line completed between Boston and Somerville, Mass.

1877 Direct current series arc lighting (developed by Brush).

1879 Direct current series arc lighting with automatic regulation developed by Thomson.

1879 First central-station arc-light system (Brush), installed, San Francisco, Calif.

1880 Jan. 27—Patent granted to Thomas A. Edison for an electric incandescent lamp having a carbon filament of high resistance.

1880 Oct. 20—The mechanical formation of secondary battery plates patented in France by Camille Faure.

1880 Direct current multiple incandescent lighting developed by Edison.

1880 Sawyer-Mann incandescent lamp patented.

1882 First incandescent central station system (Pearl Street station, New York City) placed in operation. (Edison.)

1883 Direct current 3-wire distribution system developed by Edison.

1883 Magnetic blowout principle discovered by Thomson.

1883 Gaulard and Gibbs first transformer.

News

Of Institute and Related Activities

The Institute's 50th Annual Summer Convention

THE ANNUAL summer convention this year marks the fiftieth meeting of its kind in the history of the Institute. On this occasion and in commemoration of the fiftieth anniversary of the Institute's organization, the committee has arranged for special addresses by Dr. W. E. Wickenden and Dr. William McClellan on educational and professional aspects of interest to electrical engineers, which will be given at the opening meeting. The committee also is using every endeavor to have present all officers of the Institute, all living past-presidents, and all living charter members, as well as a goodly representation of engineers from all sections. The convention will be held at Hot Springs, Va., June 25–29, 1934, with headquarters in The Homestead. Make your plans now to attend the fiftieth anniversary reunion of electrical engineers in this most attractive setting.

In addition to the fiftieth anniversary celebration, the 1934 summer convention committee has arranged an excellent schedule of events. The annual business meeting and the technical sessions will be held during the mornings, while the afternoons, with the exception of Monday and Tuesday afternoons on which the conference of officers, delegates, and members will take place, have been kept free for sports and other recreation. In the evenings, the president's reception, a get-together banquet with entertainment, and the convention banquet will be held and followed by dancing. These features and the program are given in the following columns as well as other pertinent information relative to hotel arrangements and reduced railroad rates.

Technical Sessions

The technical program includes 7 sessions: education, electrical machinery, communication, insulators, automatic stations, power generation, and instruments and measurements. The session on education and the activities of the Engineers' Council for Professional Development will be of broad general interest. The sessions on electrical machinery and communication will be more or less highly specialized and treat some of the latest developments in these phases of the art. The session on insulators is well rounded from the user's point of view as well as the manufacturer's. The subcommittee on lightning and insulators will present data on the flashover values of suspension insulators, and another paper will deal with the selection, life performance, and deterioration of insulators. Several papers by insulator manufacturers will present some of the latest developments in research and design of this product, as well as its radio influence characteristics. The automatic stations session will treat some of the latest developments in methods of load totalizing, voltage regulation, supervisory control, and automatic synchronizing. All who are interested in central stations and hydroelectric generation should find the power generation session of unusual interest. In addition, the final session on instruments and measurements will bring out some new and valuable data on sphere gap calibrations.

Entertainment Features

The president's reception, a get-together banquet with entertainment, and the convention banquet will be held on Monday, Tuesday, and Wednesday evenings, respectively. All these delightful social features will be followed by dancing. In addition, for the ladies there will be a drive to the Hotel Greenbrier, White Sulphur Springs, W. Va., where tea will be served. Facilities for bridge also will be arranged as desired. If there is sufficient registration a tournament will be arranged with prizes for the winners and runners-up.

For all persons registered at The Homestead or its Cottages an entertainment fee of $5 will be collected at time of registration. For all persons registered at Cascades Inn or elsewhere an entertainment fee of $10 will be charged. These fees will be devoted to the expenses involved in carrying out the plans of the general convention committee.

Sports

Excellent facilities are available for golf, tennis, skeet, and horseback riding at Hot Springs and its environs.

Golf: Three excellent golf links are available and the usual competition for the Mershon and Lee golf trophies will be held. The Mershon trophy is competed for on a match play handicap basis. The qualifying round for the Mershon trophy must be played on Monday, June 25. The second round, best 16, match play, will be played on Tuesday afternoon, followed by the third round on Wednesday afternoon, with the semi-final and final rounds played on Thursday morning and afternoon.

The Homestead, Hot Springs, Va., scene of the Institute's 50th annual summer convention, to be held June 25–29, 1934

The Lee trophy is awarded annually for the lowest net score for 36 holes, of which the first 18 may be the qualifying round and the other 18 must be played not later than Thursday afternoon. In addition, a putting contest, 18 holes, for the ladies will be held on Tuesday morning. Prizes for the winners and runners-up will be awarded in the above contests.

Tennis: Courts equipped for championship play are available at The Homestead. The first contests in men's singles for the Mershon Tennis Trophy competition will start on Monday, June 25. The second round will be played on Tuesday afternoon and the semi-final and final rounds will be played on Wednesday and Thursday afternoons, respectively. Contests in men's doubles, ladies' singles, and mixed doubles also will be arranged if there should be a sufficient registration for them. Prizes for the winners and runners-up will be awarded in the above contests.

Skeet: The Homestead operates a well-equipped skeet range, and this popular form of trap shooting may appeal to some members. If a sufficient number should register, a tournament will be arranged. A limited number of guns are available for rental; probably participants will desire to bring their own favorite guns for this sport. Fees are $1.25 for 25 birds; these include pigeons, shells, pull boys, and trap boys; also transportation to the shooting grounds from the hotel.

Horseback Riding: Hot Springs is surrounded by many lovely trails, and The Homestead maintains a fine stable of riding horses.

The prizes for the various sports will be presented at luncheon on Friday, June 29.

Reduced Railroad Rates

Fare and one-third for the round trip over the same route will be available to members and guests, provided 100 certificates (or 100 combinations of certificates and round-trip rail tickets with limiting dates from points from which the one-way fare is $2 or more) are validated at the registration desk. Consult your local ticket agent regarding the dates and territories to which this arrangement applies. Obtain your certificate authorized by the railroad passenger associations.

Hotel Rates and Accommodations

All rates, shown in Table I, are on the American plan and they, also, will be in effect a few days before and after the convention for any who may wish to make a longer stay at Hot Springs.

Table I—Hotel Rates, American Plan

	Rate per day per person
The Homestead	
Single room—private bath..........	$9.00
Double room—private bath—twin beds	8.00
Combinations—double room and single room, with bath between, or 2 double rooms with bath between..........	7.50
Cottages (meals at The Homestead)...	7.00
The Cascades Inn	
(2 1/2 miles from The Homestead, free transporation to and from The Homestead, meals at The Cascades Inn)	5.00

Members should make their reservations by writing directly to the hotel of their preference. For those stopping at places other than The Homestead and its Cottages, an extra charge will be made for the get-together dinner and the banquet. This extra charge is the occasion for 2 different entertainment fees listed under entertainment.

All baggage should be tagged with the owner's name before arrival, to facilitate prompt service. For this purpose, The Homestead will supply tags with the acknowledgment of each reservation. In case these tags are lost or mislaid, an additional supply may be secured on the train between Covington, Va., and Hot Springs, so that all baggage, including golf bags, guns, etc., may be properly tagged. Your careful attention to this detail will avoid delay and greatly facilitate the handling of baggage. Free transportation from trains to the hotels will be supplied with no charge for hand baggage. Heavier baggage checked and requiring the service of the baggage van will be transported from the train at 50 cents a trip, or $1 for arrival and departure.

The Cascades Inn and Golf Course at Hot Springs, Va., 2 1/2 miles from the Homestead

Register in Advance

Fill in and post promptly the mail registration card, which will be sent to members in nearby Districts. This will permit the committee to have badges ready and prevent congestion at the registration desk upon arrival. There will be a registration fee of $2.50 for nonmembers with the exception of Enrolled Students of the Institute, and the immediate families of members. This fee is in addition to the entertainment fee charged to all in attendance.

Reservations for hotel accommodations should be made by writing directly to the hotel preferred.

Notice of Annual Meeting

The annual meeting of the American Institute of Electrical Engineers will be held in The Homestead, Hot Springs, Va., at 10 a.m. on Monday, June 25, 1934. This will constitute one session of the annual summer convention which is to be held this year in Hot Springs, June 25–29.

At this meeting the annual report of the board of directors and the report of the committee of tellers concerning the ballots cast for the recent election of officers will be presented.

Such other business, if any, as properly may come before the annual business meeting may be considered.

(Signed) H. H. Henline
National Secretary

Schedule of Events

A summarized schedule of events follows: Time given is Eastern Standard Time. Capital letters A, B, etc., denote technical sessions.

Monday, June 25

9:00 a.m.—Registration
10:00 a.m.—Annual business and fiftieth anniversary meeting
Annual report of board of directors (in abstract), H. H. Henline, *national secretary*
Report of tellers' committee on election of officers; introduction of and response from president-elect
Presentation of prizes for papers
Presentation of the Lamme Medal to Dr. Lewis B. Stillwell
Addresses: Dr. W. E. Wickenden, president, Case School of Applied Science
Dr. William McClellan, past-president, A.I.E.E.
Dr. John B. Whitehead, president, A.I.E.E.
2:00 p.m.—Conference of Officers, Delegates, and Members
Golf—Qualifying round for Mershon Trophy
Tennis—Men's singles for Mershon trophy
9:00 p.m.—President's reception—dancing

Tuesday, June 26

9:00 a.m.—Registration
9:30 a.m.—(A) Education
Morning—Putting contest for ladies
2:00 p.m.—Conference of Officers, Delegates, and Members (continued)
Golf—Second round, match play—Mershon trophy
Tennis—Second round—Mershon Trophy
7:00 p.m.—Get-together banquet—entertainment, dancing

Wednesday, June 27

9:30 a.m.—(B) Electrical machinery
(C) Communication
12:00 p.m.—Directors' luncheon and meeting
2:00 p.m.—Golf—Third round—Mershon trophy
Tennis—Semi-finals—Mershon trophy
7:00 p.m.—Convention banquet—dancing

Thursday, June 28

9:30 a.m.—(D) Insulators
(E) Automatic stations
Morning—Golf—Semi-finals—Mershon trophy
2:00 p.m.—Golf and tennis finals
Afternoon—Drive for ladies to White Sulphur Springs, with tea at Hotel Greenbrier

Friday, June 29

9:30 a.m.—(F) Power generation
(G) Instruments and measurements
12:30 p.m.—Award of sports prizes at luncheon

Technical Program

Several papers on the program have been published in Electrical Engineering, April 1934 issue. The remainder are scheduled for inclusion in the June issue. Pamphlet copies of these papers will not be available, and members should take these issues with them to the convention.

Tuesday, June 26

9:30 a.m.—(A) Education, L. A. Doggett, *chairman*

Encouragement of Initiative in the Engineering Student, C. L. Dawes, Harvard University.

Industry Demands and Engineering Education, L. W. W. Morrow, McGraw-Hill Publishing Co.

The Next Generation of Engineers, C. F. Hirshfeld, The Detroit Edison Co.

Wednesday, June 27

9:30 a.m.—(B) Electrical Machinery, S. L. Henderson, *chairman*

Voltage Control of Vapor Rectifiers, D. Journeaux, Allis-Chalmers Mfg. Co.

Rectifier and Inverter Characteristics of the Grid Controlled Mercury Arc Rectifier, C. C. Herskind, General Electric Co.

Insulation Resistance of Armature Windings, R. W. Wieseman, General Electric Co.

Split Winding Transformers, D. D. Chase and A. N. Garin, General Electric Co.

Factors Influencing the Insulation Coordination of Transformers—II, P. L. Bellaschi and F. J. Vogel, Westinghouse Electric & Mfg. Co.

9:30 a.m.—(C) Communication, F. M. Craft, *chairman*

Iron Shielding for Telephone Cables, H. R. Moore, American Telephone & Telegraph Co.

A Study of Iron-Armored Cable as a Remedial Measure for Communication Circuits in a Severe Inductive Exposure, C. L. Gilkeson, Edison Electric Institute, and A. J. Hanks, Western Union Telegraph Co.

Recent Developments in Power Line Carrier, T. Johnson, Jr., General Electric Co.

The Compandor—An Aid Against Static in Radio Telephony, R. C. Mathes, Bell Telephone Laboratories, and S. B. Wright, American Telephone & Telegraph Co.

Thursday, June 28

9:30 a.m.—(D) Insulators, D. M. Simmons *chairman*

Flashover Values of Suspension Insulators and Gaps, Subcommittee on Lightning and Insulators.

Selection, Life Performance, and Deterioration of Insulators, Philip Sporn, E. L. Peterson, and V. A. Mulford, American Gas and Electric Co.

High Voltage Insulators—Research, Design, Manufacture, W. A. Smith and J. T. Lusignan, Jr., Ohio Brass Co.

The Suspension Insulator, K. A. Hawley, Locke Insulator Corp.

Future AIEE Meetings

North Eastern District meeting,
Worcester, Mass., May 16–18, 1934

Summer convention,
Hot Springs, Va., June 25–29, 1934

Pacific Coast convention,
Salt Lake City, Utah, Sept. 3–7, 1934

Radio Influence Characteristics of Insulators, G. I. Gilchrest, Westinghouse Electric & Mfg. Co

Recent Development in Suspension Insulators, G. M. Barrow, Westinghouse Electric & Mfg. Co.

A New Porcelain Post Insulator for Transmission Lines, G. W. Lapp, Lapp Insulator, Inc.

9:30 a.m.—(E) Automatic Stations, D. W. Taylor, *chairman*

Load Totalizing in the New York Metropolitan Area, F. Zogbaum, The New York Edison Co.

Electronic Type Voltage Regulators for A-C Generators, F. H. Gulliksen, Westinghouse Electric & Mfg. Co.

New Developments in the Direct Selection System of Supervisory Control, M. E. Reagan, Westinghouse Electric & Mfg. Co.

Developments in Automatic Synchronizing, H. T. Seeley, General Electric Co.

Friday, June 29

9:30 a.m.—(F) Power Generation, H. W. Leitch, *chairman*

Hydroelectric Survey—Part I, Subcommittee on Hydroelectric Survey, A. V. Karpov, *chairman.*

New York Generating System Aids Network Operation, H. C. Forbes and H. R. Searing, The New York Edison Co.

Inductive Heating and Space Limitation Problems Solved in Design of 7,000-Amp Bus, H. L. Unland and V. R. Bacon, United Engineers & Constructors, Inc., and W. B. Morton, Philadelphia Electric Co.

9:30 a.m.—(G) Instruments and Measurements, W. B. Kouwenhoven, *chairman*

Cross Current of a 5-Arm Network, A. C. Seletzky and J. R. Anderson, Case School of Applied Science.

Theory and Performance of Selsyn Instruments, T. M. Linville and J. S. Woodward, General Electric Co.

A New Current Telemeter With Pilot Coil Transmitter, L. J. Lunas and H. L. Bernarde, Westinghouse Electric & Mfg. Co.

Sphere Gap Calibrations, J. R. Meador, General Electric Co.

Rules on Presenting and Discussing Papers

At some of the technical sessions, papers will be presented only by title. This will permit the devotion of more time to discussion. At other sessions, papers will be presented in abstract, 10 min being allowed for each paper unless otherwise arranged, or the presiding officer meets with the authors preceding the session to arrange the order of presentation and allotment of time for papers and discussion. Authors will be notified officially in each case about one month in advance.

Any member is free to discuss any paper when the meeting is thrown open for general discussion. Usually 5 min are allowed to each discusser for the discussion of a single paper or of several papers on the same general subject. When a member signifies his desire to discuss several papers not dealing with the same general subject, he may be permitted to have a somewhat longer time.

It is preferable that a member who wishes to discuss a paper give his name in advance to the presiding officer of the session at which the paper is to be presented. Each discusser is to step to the front of the room and announce, so that all may hear, his name and professional affiliations. Three typewritten copies of discussion prepared in advance should be left with the presiding officer.

Other discussion to be considered for publication should be typewritten and submitted in triplicate to C. S. Rich, secretary of the technical program committee, A.I.E.E. headquarters, 33 West 39th St., New York, N. Y., on or before July 13, 1934.

Committees

The general convention committee for the 1934 summer convention consists of the following members: W. S. Rodman, *chairman;* C. A. Robinson, *vice-chairman;* R. C. Bailey, *secretary;* and E. P. Coles, R. N. Conwell, F. M. Craft, S. A. Flemister, J. T. Graff, E. L. Lockwood, W. R. McCann, and I. M. Stein. The chairmen of the various subcommittees working with the general convention committee are as follows: entertainment, C. A. Robinson; registration and hotels, E. L. Lockwood; finance, E. P. Coles; technical sessions, R. N. Conwell; and sports, J. T. Graff.

District Meeting at Worcester, May 16–18

The tenth annual meeting of the Institute's North Eastern District will be held at Worcester, Mass., May 16–18, 1934, with headquarters at the Bancroft Hotel. The technical sessions will be held at the Bancroft Hotel and in the lecture rooms of the Worcester Polytechnic Institute.

The program of the Worcester District Meeting was announced in Electrical Engineering for April 1934, p. 627–9. Since the time of publication of this program in the April issue, the paper by Hutchins and Livington has been replaced by "The Behavior of Distance Relays During System Oscillations," by E. H. Bancker and E. M. Hunter, of the General Electric Company. This paper has not previously been published in Electrical Engineering.

The session on selected subjects will be presided over by Prof. T. H. Morgan, instead of by T. A. Worcester.

The report of the Worcester Meeting is scheduled for the June issue of Electrical Engineering and the discussion of the

papers will be published as soon as they are made available. To be considered for publication, discussions should be typewritten and submitted in triplicate to C. S. Rich, secretary of the technical program committee, A.I.E.E. headquarters, 33 West 39th Street, New York, N. Y., on or before June 1, 1934.

All meetings at Worcester are scheduled to start on daylight saving time.

"Science Makes More Jobs" the Topic of an Interesting Meeting

At a meeting held in New York, N. Y., February 22, 1934, under the coöperative action of the New York Electrical Society, the American Institute of Physics, and the New York Museum of Science and Industry, a group of addresses was delivered which were devoted to showing how "Science Makes More Jobs." These addresses, delivered in an attempt to combat charges recently brought by individuals not acquainted with all the facts, were presented by prominent educators and industrial leaders. Excerpts from 3 of these addresses are presented herewith.

Address of Doctor Karl T. Compton

Sections of the address given by Dr. Karl T. Compton (F'31), president, Massachusetts Institute of Technology, Cambridge, chairman of the American Institute of Physics, and chairman of President Roosevelt's science advisory committee follow:

"The idea that science takes away jobs, or in general is at the root of our economic and social ills, is contrary to fact, is based on ignorance or misconception, is vicious in its possible social consequences, and yet has taken an insidious hold on the minds of many people. Conscious of the fallacy of this idea, but characteristically intent on their work and averse to publicity, the productive scientists of the country have thus far taken little or no part in discussions of the subject.

"It has become evident, however, that the spread of this idea is threatening to reduce public support of scientific work, and in particular, through certain codes of the N.R.A., to stifle further technical improvements in our manufacturing processes. Either of these results would be nothing short of a national calamity—barring us from an advanced state of knowledge and standard of living and soon placing us at an economic disadvantage in respect to foreign countries who have not let themselves be swayed by such a short-sighted point of view.

"Consequently the New York Electrical Society and the American Institute of Physics are combining in a national service to combat this insidious and dangerous propaganda. They do not, of course, hold that scientific and technical advances have not brought difficulties, like social growing pains. But they strive to prevent us from killing the goose that lays the golden eggs, just because some of these eggs happen to be tarnished. They would advocate careful attention to polishing the eggs, and encouraging the goose to lay more of them. In other words, they advocate intelligent and effective attention to remedy such social and economic difficulties as have accompanied the advance of science, and at the same time they advocate the further advancement of science and its applications for human welfare just as vigorously as possible. They do this because the effects of science on human welfare are preponderatingly good and beneficial. . . .

"Think for a moment where we would be if our ancestors, alarmed by the progress of science, had taken steps by codes or by public sentiment to stop its progress! . . . And if we, in this day and generation, act to stop science, our descendants will similarly miss the corresponding new advantages which they might otherwise have. . . .

"That great human benefactor, Pasteur, had a grasp of the truth when he wrote: 'What really carries us forward is a few scientific discoveries and their applications.'

"Those in charge of this meeting. . . have chosen not to try to handle the whole field of science and its effects on society but to concentrate primarily upon just one aspect of these social effects, namely, the effect of science upon employment. This is a very live issue in these days of unemployment. It is here that a misunderstanding of the effects of science are likely to be most dangerous, because of possible political influences. Let us therefore consider very briefly what these effects are.

"We will immediately admit that technological advances frequently result in labor-saving devices which throw large numbers of men and women out of work. This is distinctly unfortunate. Its evil effects can be mitigated by wise handling of these new devices; as, for example, the American Telephone and Telegraph Company has handled its introduction of automatic switching so as not to throw employees out of work.

"But the other side of the picture is immensely more significant in that the major result of science is the creation of entirely new industries which cater to new human desires, and which not only create a multitude of new jobs but which increase the per capita productiveness of men so as, first, to permit of an increasing population which is not limited by starvation and misery and, second, to reduce the hours necessary for men to labor to produce their necessities, and in this way to give them their opportunity to appreciate and experience some of the better opportunities of living which formerly were available only to those of wealth or of politically favored position.

"Let me give a few examples of what I mean: Two years ago was celebrated the centennial anniversary of the discovery of the principles of electromagnetism which underlie practically all of the modern electrical industry. According to the 1930 census there were in this country about 360,000 persons employed in the manufacture of electrical machinery and equipment, and about 676,334 people employed in the distribution of electrical materials, exclusive of the field of communication, namely, the telephone, telegraph, and radio, which contribute in addition an immense number of workers.

"I believe. . . that the argument can be made more fundamental even than this. Man has an irrepressible curiosity for new knowledge. This is the fundamental basis and urge for scientific work. Man has also an irrepressible desire to use his knowledge for the accomplishment of his desires. This is the basis of invention and of engineering. These, I believe, are so fundamentally a part of human psychology that they cannot, be fettered, though their free exercise may of course, be hampered or, on the other hand, be encouraged. The early Egyptian who discovered that a wheel driven by the current or by oxen could lift up water from the Nile for the irrigation of his fields did not worry because this invention relieved him of the job of carrying his water by hand. He simply took advantage of this invention to increase his range of interests and activities in other directions. He cultivated more land, he experimented in early science, he built monuments which he could not have done had he toiled morning to night carrying water by hand. Similarly, I believe that in the last analysis the extent of man's employment is governed by man's inherent desire and urge to do something. If science can relieve him of the more routine tasks, he is free to turn his attention to other things which excite his curiosity or satisfy his desires. In the last analysis, therefore, I believe that science simply increases man's power and the range of his activities. Most certainly, however, both theory and experience prove more conclusively that science has made jobs, not taken them away."

Address of Dr. F. B. Jewett

Excerpts from the address delivered at the same meeting by Dr. Frank B. Jewett (A'03, F'12, past-president), vice-president of the American Telephone and Telegraph Company, and president of the Bell Telephone Laboratories, Inc., New York, N. Y., trustee of the New York Museum of Science and Industry, and a member of President Roosevelt's science advisory committee, follow:

"This allegation, that science has shot its bolt, and that there should be a holiday on scientific research, of course, is nothing substantially new. Some of us have been hearing this thing for a good many years but it has reached its crisis in this economic depression. That it is a false assumption, I think is quite easily demonstrable, if one is willing to look at things in somewhat of a broad prospective. . . .

"One of the first things which appears to be of first importance—is what has happened in the Western world in the last 35 years or so, in comparison to what happened in the rest of the world, relatively. . . . Let us

go back to the period of time in the Middle Ages—or later—even up to the end of the 18th century. . . . What you find, is that goods were produced similarly in all parts of the world and that consequently, scientific progress was about the same throughout the world. . . .

"Then something happened—at about the beginning of the 19th century—in the Western world, which upset existing conditions. That something was the introduction in the western society of science—and the furtherance of the scientific principle in living conditions.

"During the 19th century, and more importantly, the first part of the 20th century, that influence has grown and what has been its result, is that it is the only major factor which has done more to correlate the markets of the Western world to those of the rest of the world. Consequently, if scientific progress is not the sole cause of whatever has happened to strengthen world relations, it is the major factor in changing existing conditions. . . . During this period of time, the population of the world has increased enormously. More people have been added to the world's population in that short period of time, than in any preceding time—and they have been added in the very places where science has found its work—in the Western world, in America particularly, and in Japan, the only one of the Oriental countries which has applied Science. . . .

"Now to the question that Science has reduced employment. It has greatly increased employment because it has increased the number of people gainfully occupied in its various aspects. Further than that, it has unquestionably increased the pleasure and ease of living in the sphere in which it has been operating. . . .

"Let us see what progress resulted from the advance in the use of science in industry. At the time of the Centennial Exposition there was no telephone system, no electric light, or power industry. There was no automotive industry. There were no aeroplanes—nothing which involved internal combustion engines. There were no chemical industries which have grown up in the last recent years. There was no motion picture machine. No talking machine. No radio—no picture transmission. We can get up a list of things that are extremely important today, which did not exist at all at the time of the Fair. Out of these have been built huge industries—the greatest outside of agriculture, which have given employment to untold thousands.

"One thing which this Exposition did and which they did not expect it to do—was that it acted as a great inspiration to the youth of the country, and the result is a vast expansion to the application of science in an enormous number of industries and activities which had not so been benefited before. . . .

"If one is willing to look at facts in broad prospective, it seems to me, that one cannot but see that history, in the last 150 years at least, has proved that scientific research, applied to the forces of life, has resulted in better living conditions and an increase of employment for people who are gainfully working in scientific industries. I think that any argument to the contrary is based on complete ignorance—or based on a too-narrow survey of specific, unrelated facts."

Address of Dr. R. A. Millikan

Excerpts from the address delivered at the meeting on "Science Makes More Jobs" in New York, N. Y., February 22, 1934, by Dr. R. A. Millikan (M'22, HM'33), director of the Norman Bridge Laboratory of Physics and chairman of the executive council of California Institute of Technology, Pasadena, and a member of President Roosevelt's science advisory committee, follow:

"If anyone. . . .doubt that the common man. . . .is vastly better off here today in depressed America than he has ever been at any other epoch in history, I beg of you to begin to read carefully a bit of that history—or if you haven't time for that, then to make friends with some historian and pump him on the living conditions of the common man in any preceding age as compared with those existing right now in the midst of the world's greatest depression... If you haven't even time for either of the foregoing procedures then let me ask you at least to take 10 minutes to read a brief article by Henry M. Robinson published in the December 1933 number of the *Readers' Digest* entitled, "No Time Like the Present." Its simple statement of historic facts will be an eye-opener to some of you. . . .Let me first quote Mr. Robinson's conclusions from his historic studies. He says, 'For all its chafings and imperfections our age is superior in security, comfort, leisure, and economic rewards to any other period or condition of life that ever existed in this sweating, tear-drenched world.' Or again, 'In terms of political justice, economic coöperation, health, happiness, and human sympathy there has, as yet, been no time like the present.'

"For what is science actually responsible in this American civilization of ours? Let me first give to that question the answers upon which there will and can be no essential disagreement. Science and its applications have so increased the efficiency of labor that here in the United States we produce more of the fundamental food-stuffs, clothing, building materials, and fuels than we, just now, know what to do with; and in spite of the present jam in our social machinery which we call the depression the great bulk of all this produce goes now, and always has gone to the common man, that is, to labor. So nearly is that true that any economist will tell you that the standard of living in the different countries of the earth is in general directly proportional to the total productivity of these countries per inhabitant. That is why in spite of the depression the standard of living here has remained relatively high and there has been no appreciable starvation, while in Russia where the opportunity for, and stimulus to, individual effort has been removed through state paternalism, not less than 5 million people, according to Whiting Williams, starved to death last year, and also where he says that the well-being of the common man is incomparably lower than it is here when at its worst.

"In the second place I need to bring forth no figures to convince anybody that the productivity of labor, brought about by the applications of science in America, has opened up to the common man the opportunities of leisure such as he has never known at any other time or place. . . .

"Every labor-saving device creates in general as many, oftentimes more, jobs than it destroys and the new jobs are in general better for the individual affected, and much better for society as a whole than the old ones. Labor-saving devices do not in general destroy the jobs that demand intelligence. They cannot do it. The heavy, grinding, routine, deadening jobs are the ones that machinery destroys. . . .

"Taking the long range view, not the short range one, I have no hesitation whatever in saying that there is no such thing as technological unemployment. By what authority do I say that? By the authority of the official census of the United States. This lists every decade the percentage of the population 'gainfully employed.' This was 34 per cent in 1880 and almost exactly 40 per cent in 1930—a depression year—and it has shown a steady increase decade by decade, save for a negligible drop from 1920—when war conditions were still on—to 1930. In other words in this precise period in which science has been applied most rapidly to industry the percentage of our population living by means of jobs has continually increased—comment enough on the soundness of the judgments of those who attribute the depression, which seems to me to be in fact a purely social phenomenon, to technological unemployment."

Bell Telephone System Centralizes Its Researches

Announcement has been made that the research activities of the Bell Telephone System have been centralized through the consolidation of the development and research department of the American Telephone and Telegraph Company with the Bell Telephone Laboratories, Inc. A brief history of the research organization of the Bell system follows:

Before there was a telephone there was a telephone laboratory. In a corner of a Boston workshop Alexander Graham Bell carried on his researches. Ever since that time the parent company of the Bell Telephone System, which evolved from his invention, has maintained a telephone laboratory. In the early years of the Bell System the laboratory was at its headquarters in Boston. Two other laboratories, meanwhile, developed in conjunction with the Western Electric Company, the manufacturing unit; one in Chicago, and the other in New York. In 1907, these 3 laboratories were consolidated into a single unit in New York City. This combination of laboratories was then operated as the engineering department of the Western Electric Company.

Not all, however, of the research problems of communication, in which the American Telephone and Telegraph Company was interested, were of a laboratory character. In its own organization, therefore, that company continued to maintain a development and research group. This group

stood intermediate between the laboratory research and the actual operation of communication systems.

Bell Telephone Laboratories Organized

By 1925 the work of the laboratory unit had so grown in range and in intensity, and the magnitude of the personnel involved, that it could best be carried on in a corporation devoted solely to research and development. The organization, therefore, which had been maintained and operated as the engineering department of the Western Electric Company since 1907, was incorporated as Bell Telephone Laboratories. Its dual responsibility to the American Telephone and Telegraph Company, for fundamental researches, and to the Western Electric Company as the manufacturing unit of the system, for the embodiment of the results of these researches in designs suitable for manufacture, was emphasized in its corporate organization. The laboratory company is owned jointly by the American company and by the Western Electric.

In the executive direction of the work of the laboratories there was emphasized the responsibility, which the American Telephone and Telegraph Company has assumed, as the corporate successor of Alexander Graham Bell, for ensuring to its associated companies in the system the technical progress of the communication arts. This was accomplished in part by organization, and in part by the choice of executive personnel. As president of the laboratories there was elected Dr. F. B. Jewett (A'03, M'10, F'12, and past-president). Dr. Jewett was also elected vice-president of the American Telephone and Telegraph Company to have charge of its research and development activities. Coördination of all the research activities within the American company and within the laboratory unit was thereby assured under the supervision of a single executive.

It was while the laboratories were operated as the engineering department of the Western Electric Company that there came into existence the laboratory group known as the "research department." Its head in its early days was Dr. E. H. Colpitts (A'11, F'12), who had entered the Bell System in its Boston laboratory. In 1924 he returned to the American company as assistant vice-president to take charge under the late General J. J. Carty (A'90, M'03, F'13, member for life and past-president), of the "development and research department" of that company; and he continued in that capacity under Dr. Jewett.

The department of development and research in the American Telephone and Telegraph Company has had that particular name only since 1919. Its characteristic activities, however, preceded by years the adoption of its name, for they were part of those of the engineering department of the American company. That department, organized under General J. J. Carty, as chief engineer, was concerned with the technical progress of the telephone art, the establishment and maintenance of suitable standards, and the solution of peculiar problems arising in the operating field.

In 1919 there was taken another step in functional organization. The much augmented engineering department was divided into 2 groups, namely, that concerned with problems of operation and engineering and that concerned with problems of development and research. The first mentioned problems became the particular care of Bancroft Gherardi (A'95, M'04, F'12, member for life, and past-president), who was then appointed vice-president of the American Telephone and Telegraph Company; and the research problems continued to be the care of Vice-President J. J. Carty (deceased 1932). It was to the leadership of this department that Dr. Jewett succeeded when he returned to the American company from the Western Electric.

Further Centralization

March 1, 1934, a further centralization of the research activities of the Bell System was accomplished. The development and research department of the American Telephone and Telegraph Company and the laboratories were consolidated. All of their activities are now carried on under the corporate name of Bell Telephone Laboratories. A year earlier when this centralization was first definitely projected Mr. Colpitts was elected vice-president of the laboratories, in charge of its operation. These 2 units which are now merged have had, therefore, for almost a year, identical executives.

The combination with Bell Telephone Laboratories of the development and research department of the American company means an organization with a marked increase in responsibilities, and concurrently a commensurate increase in its technical efficiency. The direction of the enlarged organization continues to be the responsibility of Dr. Jewett in his dual capacity as vice-president of the American Telephone and Telegraph Company and president of Bell Telephone Laboratories.

Obituary

William Joseph Hammer (A'87, M'87, F'12, and life member) retired, major, U.S. Army, long regarded as one of the country's foremost electrical experts, who served the Institute as vice-president (1891–93) and manager (1893–96), died of pneumonia in New York, N. Y., on March 24, 1934. He was born at Cressona, Pa., February 26, 1858, and was educated at public and private schools in Newark, N. J., and at the University of Berlin and the Technische Hockshule (Berlin). Major Hammer became an assistant to Edward Weston in the Weston Malleable Nickel Company in 1878 and the following year entered Edison's laboratory at Menlo Park, N. J., as general assistant, where for a long time he had charge of the tests and records on incandescent lamps. In 1880 he was made chief electrician of the first Edison Lamp Works, at Menlo Park, N. J., and in 1881, chief engineer of the English Edison Company. He was the Edison representative at the Paris Electrical Exposition, constructing what is reported to be the first central station for incandescent electric lighting in the world at Holborn Viaduct, which was put into operation in 1882. He also installed the plant using 12 Edison dynamos at the Crystal Palace Electric Exposition (1882) and Edison's Paris Exhibit, 1889. In 1883 he became chief engineer of the German Edison Company (now known as the Allgemeine Elektricitaets Gesellschaft) and installed many plants through Germany. At the Berlin Health Exposition that year Major Hammer placed on exhibition his invention of the automatic motor-driven "flashing" electric lamp sign. He returned to the United States in 1884 to take charge of the interests of Mr. Edison and of 8 Edison companies at the Franklin Institute Electrical Exhibition in Philadelphia and became confidential assistant to the president of the parent Edison Electric Light Company. In 1889 he was Edison's personal representative at the Paris Exposition, setting up and operating all the Edison inventions; for this he was made Chevalier of the Legion of Honor (France, 1925). From 1884 to 1885 he was chief inspector of central stations of the Edison company. In 1886 he was chief engineer and general manager of the Boston Edison Company. He was one of the incorporators and trustees of the Sprague Electric Railway and Motor Company. From 1890 until his death, he carried on a consulting practice and maintained offices in New York. Among his important achievements were the installation of the 8,000-light plant of the Ponce de Leon Hotel at St. Augustine, Florida, the largest private plant in the world at that time, overhauling of the Jacksonville Edison plant which had been struck by lightning, and installation of the electrical effects at the Cincinnati Exposition of 1888. He early advocated the use of radium in treating cancer and he gave a series of 88 lectures and published the first book on the subject, entitled "Radium and Other Radioactive Substances." He was an aviation enthusiast and one of the first to privately own an airplane. At the entrance of the United States into the World War he was appointed a major on the general staff of the Army in the inventions section of the War Plans Division, and later in the Operations Division of the Army War College at Washington. Major Hammer was active on the committee on Local Meetings which studied and reported on the advisability and plans for establishing local meetings, now referred to as local Sections, of the Institute in 1893. In 1906–07 he represented the Institute at the Hall of Fame ceremonies. In 1932 he was a member of the special committee on the Edison Memorial. He was the recipient of several scientific honors, including the Elliott Cresson gold medal; John Scott legacy medal and premium; the grand prize of the St. Louis Exposition, 1904; gold medal, St. Louis Exposition, 1906. He was awarded the World War medal (U.S.) and the World War medal (New York State), 1920. He was an officer and member of numerous societies, including the American Physical Society, New York, the Franklin Institute, Edison Pioneers,

American Acoustics Electrical Society, and the Aeronautical Society.

George Owen Squier (A'91, F'19, and member for life), retired, major-general, U.S. Army, Washington, D. C., who attained distinction in the electrical field because of his early work in the invention of the multiplex telegraphy systems, and development of a monoplane system of communication for transmitting broadcast programs over telephone wires, died of pneumonia at the George Washington Hospital, Washington, D. C., March 24, 1934. He was a researcher of some note and while some of his ideas did not prove practically advantageous, many of them were suggestive of new lines of attack and stimulated research and investigation, this particularly true in regard to his valuable suggestions concerning submarine cable telegraphy and high-frequency multiplex operation. He was born March 21, 1865, at Dryden, Michigan, and was educated at the United States Military Academy, graduated in 1887, and at Johns Hopkins University where he studied electrical engineering and general physics for 3 years subsequently. He was a fellow of the university in 1891 and a fellow by courtesy the following year. Some years later, in 1903, he received the Ph.D. degree. He entered the military service as a second lieutenant of artillery, but was transferred later to the Signal Corps, attaining in 1917 the rank of chief signal officer of the Army and in 1917 major-general, retiring in 1924. He had served as military attaché at the American embassy in London from 1912 to 1913. During the World War he founded the Signal Corps School at Leavenworth, Kansas. He represented the War Department at the international conference on electrical communications at Washington in 1920 and the State Department on a committee of the conference in Paris the following year. He was a technical adviser at the Washington Arms Conference in 1921. His interest in electrical communication dated from the early days of his military career. Over a long period of years he was in responsible charge of the electrical work of the Signal Corps. In 1900–02 he commanded the U. S. S. "Burnside" in laying the cable telegraph of the Philippines. He put his multiplex telegraphy system into actual practice on a 3-mile line between the laboratory of the Signal Corps Bureau of Standards in Washington and the Signal Corps Laboratory and filed the patent for it in 1910, in the name of the people. He first demonstrated the amplifying apparatus which enables a physician to make a stethoscopic study of a patient's heartbeats at a distance of hundreds of miles. He was awarded the Elliott Cresson gold medal and the Franklin medal for his researches. He held the distinguished service medal of the United States. He was a Knight Commander of the Order of St. Michael and St. George of Great Britain, a Commander of the Order of the Crown of Italy, and a Commander of the Legion of Honor of France. He was a fellow of the London Physical Society and the Royal Institute of Great Britain, and a member of the National Academy of Sciences.

Membership

Recommended for Transfer

The board of examiners, at its meeting held April 11, 1934, recommended the following members for transfer to the grade of membership indicated. Any objection to these transfers should be filed with the national secretary at once.

To Grade of Fellow

Funk, Nevin E., vice-pres., in charge of engg., Phila. Elec. Co., Pa.
Goodale, Josiah E., E.E., N. Y. & Queens Elec. Lt. & Pwr. Co., Flushing, N. Y.
Hill, Frederick W. L., engr., Potomac Elec. Pwr. Co., Washington, D. C.
Smith, L. G., asst. to gen. supt., Consolidated Gas Elec. Lt. & Pwr. Co., Baltimore, Md.
Weber, Ernst, research prof. of E.E., Polytechnic Inst. of Bklyn., Bklyn., N. Y.

To Grade of Member

Bjorndal, Magnus, chief engr., The Daven Co., Newark, N. J.
Boyce, Edward O., engg. asst., Brooklyn Edison Co. Inc., N. Y. City.
Bush, Richard M., supt., elec. dept., Virginia Elec. & Pwr. Co., Williamsburg.
Carr, John L., asst. to E.E., Potomac Elec. Pwr. Co., Washington, D. C.
Curtis, Ralph F., asst. E.E., Western Mass. Companies, Springfield.
Dudley, Homer W., telephone engg., Bell Tel. Labs., Inc., N. Y. City
Grigsby, Logan C., E.E., Pub. Serv. Co. of Okla., Tulsa.
Knopp, Otto A., chief of bureau of tests and inspection, Pacific Gas & Elec. Co., Emeryville, Calif.
Lamb, John F., industrial motor engg. dept., Westinghouse Elec. & Mfg. Co., E. Pittsburgh, Pa.
Maunder, Sydney T., power transformer engr., Gen. Elec. Co., Pittsfield, Mass.
Webber, Thomas T., tour chief-dispatcher in charge of tour, N. Y. Fire Dept., Woodhaven.

Applications for Election

Applications have been received at headquarters from the following candidates for election to membership in the Institute. If the applicant has applied for direct admission to a grade higher than Associate, the grade follows immediately after the name. Any member objecting to the election of any of these candidates should so inform the national secretary before May 31, 1934, or July 31, 1934, if the applicant resides outside of the United States or Canada.

Brown, L. E., Westinghouse Elec. & Mfg. Co., Salt Lake City, Utah.
Burroughs, H. A., Dept. of Pub. Works, Olympia, Wash.
Burton, R. W., 1523 Chapel St., New Haven, Conn.
Cain, B. M., Gen. Elec. Co., Schenectady, N. Y.
Callis, P. A., Louisville Gas & Elec. Co., Ky.
Candler, M. A., Southern Bell Tel. & Tel. Co., Charlotte, N. C.
Christensen, H. D., Pub. Serv. Dept., City of Glendale, Calif.
Coon, C. C., 600 Fuller St., Oakland, Calif.
Craig, S. A., Louisville Gas & Elec. Co., Ky.
Davison, A. L., Empresa Telefonos Ericsson, S. A., Mexico, D. F., Mexico.
Fettig, J. J., Duncan Elec. Co., Lafayette, Ind.
Floyd, J. L., Southern Bell Tel. & Tel. Co., Charlotte, N. C.
Fuller, A. W., Adrian, Ga.
Gilcrest, R. V., Box 305, Carlyle, Ill.
Greenfield, E. W., Johns Hopkins Univ., Baltimore, Md.
Gregory, G. A., Dept. of Pub. Works, Olympia, Wash.
Grimmett, R. B., Arkansas Pwr. & Lt. Co., Marion
Hedke, H. A. W. (Member), 726 Edmund St., St. Paul, Minn.
Herzenberg, A., Gen. Elec. Co., Pittsfield, Mass.
Hibben, S. G., Westinghouse Lamp Co., Bloomfield, N. J.
Jessop, R. A., Am. Tel. & Tel. Co., Chicago, Ill.
Johnson, L. N., Meter Serv. Corp., Chicago, Ill.
Jones, H. L., Southern Bell Tel. & Tel. Co., Charlotte, N. C.
Keane, J. M., Va. Elec. & Pwr. Co., Petersburg, Va.
Kemp, J. W., 554 Arden Place, Toledo, Ohio.
Koenigsberg, M., 868 Whitlock Ave., N. Y. City.
Krog, F. G. F., Potomac Elec. Pwr. Co., Washington, D. C.
Kurtichanof, L. E. (Fellow), Ry. Exchange Bldg., Portland, Ore.
Lantz, G. J., Lantz Elec. Co., Orlando, Fla.
Leake, W. S., Gen. Elec. Co., New Orleans, La.
Leavitt, S. M., 128 32nd St., Woodcliff, N. J.
Leeds, D. A., Northern Ind. Pub. Serv. Co., Hammond, Ind.
Long, R. P., Bell Tel. Co. of Pa., Phila.
McGovern, W. R., Jr., Wis. Tel. Co., Milwaukee.
McKenzie, D. B., c/o Mrs. Stevens, 14 Clinton St., Cambridge, Mass.
McWilliam, C. E., Canadian Gen. Elec. Co., Ltd., Toronto, Ontario, Can.
Meyerend, F. M., John A. Roebling's Sons Co., Trenton, N. J.
Miller, R. A., Bell Tel. Lab., Inc., N. Y. City.
Molis, B. W., Denver & Rio Grande Western R. R. Co., Denver, Colo.
Morgan, M. I., Memphis Pwr. & Lt. Co., Tenn.
Nelson, O. L., Southern Calif. Tel. Co., Los Angeles, Calif.
Nishimura, B., Japanese Government Ry., N. Y. City.
Plaisted, R. J., P. O. Box 31, Brecksville, Ohio.
Ruhlin, L. H., Libbey-Owens Ford Glass Co., Toledo, Ohio.
Sevouny, H., Elec. Engg. & Contracting Co., N. Y. City.
Sievers, E. S., Weston Elec. Istrument Corp., Newark, N. J.
Sinclair, B. G., Dept. of Pub. Works, Olympia, Wash.
Skrynski, W. J., Hydro Elec. Pwr. Comm. of Ontario, Hydro, Ont., Can.
Smith, A. V., Gibbs & Hill, N. Y. City.
Steensen, A. P., Foxboro Co., Foxboro, Mass.
Swan, H. C., Sewerage & Water Board, New Orleans, La.
Towner, J. M., 537 Chateau Ave., Baltimore, Md.
Venturine, J. B., Industrial Elec. & Engg. Co., Portland, Ore.
Weeks, F. D., Commonwealth Edison Co., Chicago, Ill.
Whitman, E. B. (Member), The West Penn Elec. Co., Pittsburgh, Pa.
Williams, E. W., Gen. Elec. Co., Baltimore, Md.
Williams, G. S., Cypress, Ill.
57 Domestic

Foreign

Appadurai, V. P., Electricity Dept., Chepauk, Madras, India.
Bowen, D. H., Cape Times Ltd., Cape Town, South Africa.
Norinder, E. H. (Member), Univ. of Uppsala, Husyborg, Uppsala, Sweden.
Oswald, T. D., Newcastle & District Elec. Ltg. Co., Ltd., Newcastle-upon-Tyne, Eng.
Soderquist, C. G. D., Trafikaktiebolaget Grangesberg-Oxelosund, Grangesberg, Sweden.
Vepa, V. L. R., Indian Inst. of Science, Bangalore. S. India.
Young, A. H. (Member), Jamaica Pub. Serv. Co., Ltd., Kingston, Jamaica, B. W. I.
7 Foreign

Addresses Wanted

A list of members whose mail has been returned by the postal authorities is given below, with the address as it now appears on the Institute record. Any member knowing of corrections to these addresses will kindly communicate them at once to the office of the secretary at 33 West 39th St., New York, N. Y.

Bonell, R. K., 45 Clifton St., Newark, N. J.
Brayman, Chas. E., c/o J. J. Murphy & Son, 38 Ford St., Hartford, Conn.
Chilberg, Ernest E., Gen. Elec. Co., 230 S. Clark St., Chicago, Ill.
Crowder, H. G. Y., 1019 Nelson St., Vancouver, B. C., Can.
Darcy, Harris B., 305 M. & M. Bldg., Houston, Texas.
Dean, George H., Corrie, Old Shoreham Road, Shoreham-by-Sea, Eng.
Garvey, Fred A., 4144 Cottage Grove, Chicago, Ill.
Goulding, Harold, 404 W. 116th St., New York, N. Y.
Gray, L. Tenney, Jr., 6452 Hillegas Ave., Oakland, Calif.
How, John H., 42 Wai Oi Road East, Canton, China.
Isler, Harry F., 108 W. Harris Ave., San Angelo, Texas.
MacDonald, Robert, 6 Rue Nicolas Charlet, Paris, France.
Miller, Frank D., Box 34, Yatesboro, Pa.
Nemkowski, B., 104–25 115th St., Richmond Hill, N. Y.
Pauli, Henry F., 217 Greylock Pkwy., Belleville, N. J.
Sparks, Losey D., 1507 Sherwin Ave., Chicago, Ill.
Valier, Chas. E., Jr., 1804 Tel. Bldg., St. Louis, Mo.